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PROGNOSIS, TREATMENT, TECHNIC
OF OPERATION, COMPLICATIONS
AND SEQUELS

↓
BY

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PHILADELPHIA

FOURTH EDITION
THOROUGHLY REVISED

CONTAINING FOURTEEN ILLUSTRATIONS

PHILADELPHIA
P. BLAKISTON'S SON & CO.
1012 WALNUT STREET
1913

WI, 535
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TO THE MEMORY OF MY FATHER

J. M. DEEVER, M. D.

WHOSE CHARACTER AND STERLING QUALITIES AS A PHYSICIAN HAVE
BEEN THE GUIDING INFLUENCES OF MY PROFESSIONAL LIFE

THIS BOOK IS AFFECTIONATELY DEDICATED

PREFACE TO THE FOURTH EDITION

On the appearance of the last edition it seemed that the field of appendicitis had been so thoroughly tilled that there was small chance for further growth. That such was not the case is best evidenced by the fact that it has been found necessary practically to re-write sections of the book. In doing this the intensely practical nature of the subject has been kept uppermost in mind, the chief objects being to portray the disease in its clinical aspects for the benefit of student and practitioner whose opportunities for extensive special experience are necessarily limited, and to advocate those methods of treatment which the personal experience and unabated interest of years have led the author to believe to be most salutary. The recent advances in the treatment of peritonitis in general, and of appendicular peritonitis in particular, have necessitated entire revision of that important subject with explicit formulation of our present views.

The importance of chronic appendicitis has increased during the past few years and its various and obscure clinical manifestations have been more clearly delineated. The place and meaning of the leukocyte count and the differential formula have continued to provoke discussion and are nearer solution. Lane's bands, Jackson's membrane and the mobile cæcum have successively been invoked to account for symptoms commonly ascribed to chronic appendicitis which in some cases are not abolished by removal of the appendix. The extent to which they are a factor is still a question of interest.

We have wished to make little change in the chapter on Pathology from the Master hand of the late Dr. A. O. J. Kelly, but few additions or erasures having been found necessary. Increasing experience has made it possible to add a more adequate discussion of carcinoma of the appendix.

I wish to acknowledge my obligations to Dr. J. Bernhard Mencke for a large amount of preliminary work in connection

with the revision; to my clinical assistant, Dr. Damon B. Pfeiffer, whose familiarity with my work and methods has assisted greatly in the satisfactory exposition of the subject, and who, with the assistance of Dr. Alexander Randall, has brought the chapter upon pathology up to date; to Dr. A. D. Whiting for helpful criticism and the preparation of the index: to my resident physicians in the German Hospital for help with the records; finally to my secretary, Miss Patterson: all of whom have helped to lighten the labors of authorship.

CONTENTS

	PAGE
PREFACE	vii
TABLE OF CONTENTS	xi
DESCRIPTION OF THE ILLUSTRATIONS	xii
HISTORY	I
ANATOMY	41
FUNCTION OF THE CÆCUM AND APPENDIX	66
CLINICAL ÆTIOLOGY	69
PATHOLOGY	80
The Lesions of the Appendix	83
The Peritonitis and Its Consequences	126
The Bacteriology	146
The Pathogenesis	154
SYMPTOMATOLOGY	175
Acute Appendicitis	176
Chronic Appendicitis	189
APPENDICITIS IN CHILDREN	196
TYPHOID APPENDICITIS	202
DIAGNOSIS	209
DIFFERENTIAL DIAGNOSIS	219
THE BLOOD IN APPENDICITIS	252
PROGNOSIS	258
TREATMENT	264
Technic of Operation	277
AFTER-TREATMENT	323
COMPLICATIONS AND SEQUELS	335
Complications of Appendicitis	335
APPENDIX	355
MEDICAL TREATMENT	355
LIST OF NAMES	361
GENERAL INDEX	367

ILLUSTRATIONS

	PAGE
FIG. 1. From the "Anatomy" of Andreas Vesalius, published in 1543. The 7th and 8th figures from the 5th book	3
FIG. 2. Illustration from the work on the "Dissection of the Human Body" by Stephanus, published in 1545, showing the cæcum and the appendix.	5
FIG. 3. The four primary types of cæcum.	44
FIG. 4. Positions of the appendix: under mesentery; in pelvis; outer side of cæcum.	48
FIG. 5. Positions of the appendix: coiled up behind cæcum; lying down and out on iliac muscle; abnormally long appendix extending beyond hepatic flexure of colon.	49
FIG. 6. Positions of appendix: on top of mesentery; on outer side of ascending meso-colon; and in contact with external iliac artery.	51
FIG. 7. An unusual position of the appendix.	52
FIG. 8. Vascular supply of right iliac fossa.	57
FIG. 9. The ileo-colic fossa.	60
FIG. 10. The ileo-cæcal fossa.	62
FIG. 11. The sub-cæcal fossa.	63
FIG. 12. Myxosarcoma of appendix and meso-appendix.	125
FIG. 13. Intussusception of appendix.	251
FIG. 14. Skin incisions for appendicitis.	281

APPENDICITIS.

HISTORY OF APPENDICITIS.

The gradual development of any department of science is always an interesting study; and this is true to an unusual degree of the search for the real cause of various pathological phenomena which have been recognized from the time of the Father of Medicine as occurring in the right iliac fossa. So many times does it appear that acute observers stumbled on the very threshold of the discovery that the original lesion in these conditions was in the vermiform appendix, that it seems scarcely credible that for not much more than twenty years have we had any adequate knowledge of appendicitis.

As in other regions of the body, so in the neighborhood of the cæcum, a thorough appreciation of the anatomy of the parts concerned was required before students of the subject were prepared to elucidate the pathological conditions at times found there. As Galen says, in the quaint phraseology of Peter Lowe, "Hard is it to cure any disease except we first know the nature and situation of that part whereupon we work, as also the cause of the disease; otherwise neither salve is able to prognosticate of the event, nor cure the same." So it appears expedient to review the rise of knowledge of the anatomy of the appendix first, then to discuss the clinical side of the question, and finally to trace briefly the progress of the treatment employed in these cases.

Appendicitis

Fig. 1.

ANDRÆE VESALII

Bruxellensis, Scholæ
medicorum Patavinæ professoris, de
Humani corporis fabrica
Libri septem.

Basileæ, officina
Joannis Oporini,
Anno salutis reparatæ MDXLIII.
Mense Junio.

- H, Ventriculi portio, quæ inferius ventriculi constituit orificium, seu intestinorum principium quod hic chordula ligatum fiximus.
- I, K, Pars intestinorum ab I ad K protenda, vulgato nomine nunc duodenum intestinum, nunc intestinum duodenum digitorum longitudine, mihi vocatur.
- L, Jejuni intestini initium, graciliumque intestinorum sedes, ubi primum in anfractus convolvi atque antrorsum assurgere incipiunt.
- M, Ilei intestini terminus, et gracilium intestinorum finis. Verum quam sede jejuni intestini terminus, aut ilei intestini principium sit ponendum, augurari nequeo, quum toto ductu qui ab L in septima figura in eadem et octava ad M usque pertinet, nullibi discrimen commonstret, quo jejuni ab ileo liceret interstinguere.
- N, Extuberans crassorum intestinorum initium.
- O, Hoc intestinum mihi cæcum nuncupatur, non admodum contententi an quis eo nomine aliam crassorum intestinorum partem donari velit: modo is non adeo nomen sit studiosus, ut illorum occasione ea intestinorum fabrica negligat, quæ in partium aliarum constructione sedulo inquirimus.
- N, P, Q, R, S, T, Colum intestinum his characteribus insignitur, verum singuli privatim aliquid notant. N enim ad P usque coli intestini ductum notat, a dextri renis sede ad jecoris usque cavum pertinentem. A P vero ad Q coli ductus notatur, secundum ventriculi fundum a jecoris cavo ad lienis usque regionem protensus. A Q autem ad R ductus coli insinuat, a lienis regione ad pubis os, secundum sinistrum ile procedens. Cæterum ab R ad S coli indicatur ascensus anfractusque quem sursi ad umbilici usque regionem molitur. At S ad T usque progressum notat, ducti nunc ascensus ad recti intestini initium.
- V, V, Depressa coli intestini sedes.
- X, X, Coli intestini utrinque extuberantes semiglobuli, quos cellulas vulgus vocat.
- Y, Recti intestini initium. Quicquid vero sub Y consistit, rectum est intestinum.
- Z, Portio meatus bilem in intestina proferentis.
- a, Musculus recti intestini finem orbiculatim amplectus, fæciumque excretioni præfectus.
- b, c, Duo muscoli rectum intestinum virorum peni et mulierum uteri cervici intervntu musculosæ substantiæ connascitur.

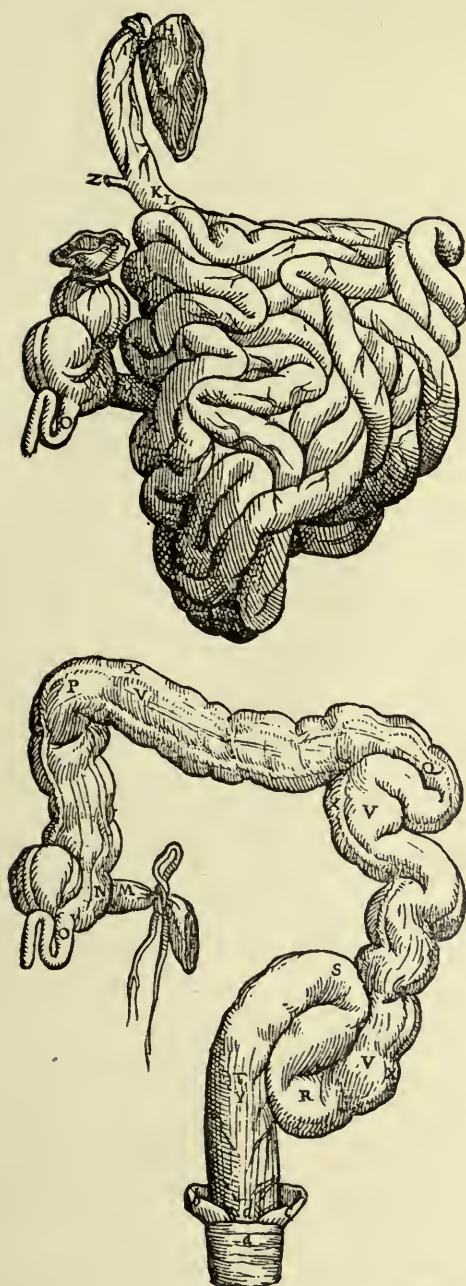


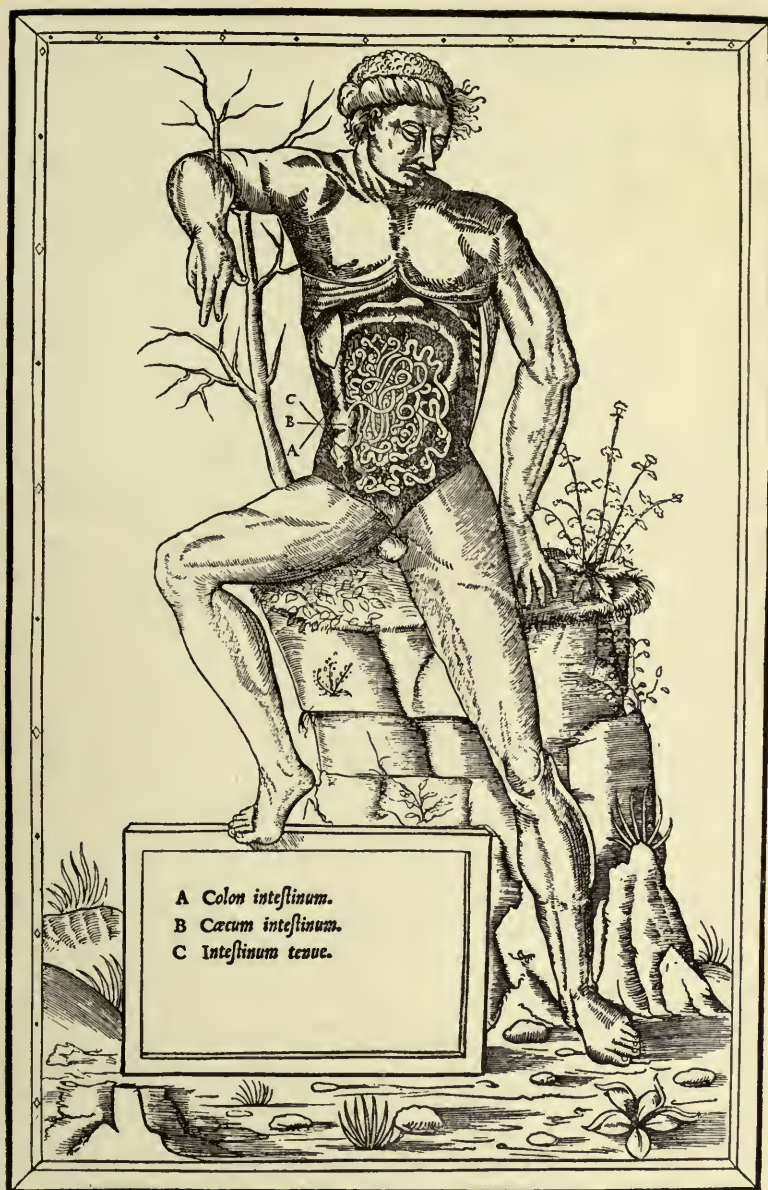
FIG. 1.—From the "Anatomy" of Andreas Vesalius, published in 1543. The 7th and 8th figures from the 5th book.

ANATOMICAL DATA.

It has always been a mooted question whether the ancients—Hippocrates, Celsus, Aretæus, Galen, and others—ever dissected the human body. Vesalius, writing in 1543, implied that Galen did not describe an appendix to the caput coli because he dissected only monkeys, which have no appendix; and as Galen, who of all the ancient writers gave by far the most complete anatomical descriptions, thus ignored so important an organ, it is readily understood that those who immediately followed him, and even the medical writers of the middle ages, made no mention at all of the appendix.

Not until 1522 A.D. is any reference to this structure to be found. In that year Berengarius Carpus, Professor of Surgery at Pavia and Bologna, published a work on anatomy in which he spoke of there being found at the end of the cæcum a certain "additamentum," "empty within, and in breadth less than the smallest finger of the hand, and of a length of three inches or thereabouts." As Berengarius is believed to have been the first modern who practised dissection it is probable that this observation was original with him. Vesalius, writing twenty-one years later, proposed that this "appendix" should properly be called the cæcum, inasmuch as that part generally termed cæcum is not a cæcum, or blind sac, but has in reality three openings, one each into the ileum, the colon and the appendix. He gave several illustrations of the abdominal viscera, showing the appendix curled upon itself, both in the body, and also removed with the whole bulk of the intestines. Two years afterward, in 1545, Stephanus published at Paris his work on the dissection of the human body. He made no mention at all of the appendix in his text, saying plainly that the cæcum was called because it had no outlet at its lower extremity; however, he published a very curious plate, showing the appendix dangling from a very capacious cæcum. He added the information, quoted nearly word for word from Galen, that in some birds the cæcum is double, "for stronger action."

Ambroise Paré wrote in 1582 that "This intestine (cæcum) has a long and narrow apophysis, which some have thought, evidently



DE DISSECTIONE PARTIUM CORPORIS humani libri tres, a Carolo Stephano, doctore Medico, editi. Una cum figuris et incisionum declarationibus, a Stephano Riverio Chirurgo compositis.

Parisiis

Apud Simonem Colinaeum.

1545.

FIG. 2.—From Charles Estienne's work on the "Dissection of the Human Body," published in 1545. This illustration is from page 172.

erroneously, slips down into the scrotum for it is prevented by its close adherence to the peritoneum." He added that the majority of anatomists of his time understood by the term *cæcum* this apophysis which he had just described.

Fallopian wrote in his "Anatomy" which was first published in 1561, as follows: "After the small intestines follow the large, the beginning of which is the *cæcum*, which in man is so small that it resembles a worm rather than an intestine. For it appears that the extremity of the colon ends off in this; and that transversely from where the *cæcum* arises the ileum is continued, so that the colon appears to divide into two branches, the shorter being the *cæcum*, the longer the ileum. The *cæcum* is so called because it has only one opening. In some animals, especially hogs, monkeys, dogs, and oxen, it is very large, and seems to serve the purpose of delaying the *fæces* for some time, lest they should too soon escape from the body through the large bowels, which is not so apt to occur in man on account of his erect posture." Fallopian appears to have been the first writer to compare the appendix to a worm. References to its vermiform appearance are frequent after his time. Thus Bauhin published in 1597 an explanation of the ileo-cæcal valve, in which he wrote of the "appendix lumbricum" in a manner which shows it to have been already well recognized in 1579. He also proposed the ingenious theory that the appendix served during intrauterine life as a receptacle for the *fæces*; from which it seems not improbable that he confounded it with the diverticulum described nearly two hundred years later by Meckel, whose name it bears. In his anatomical atlas, Bauhin gave illustrations calling the *caput coli* the "*cæcum* of Galen," and the appendix vermiformis the "*cæcum* *intestinum posteriorum*." Laurentius, also, in 1600 described the appendix as a twisted worm—"appendiculam contorti lumbrici specie."

Vidus Vidius entered into more detail. He described two coats to the intestines, and said that to these is added a third tunic, from the peritoneum, which not only adds firmness, but binds all the intestines to the back and vertebral column. Joined to the *cæcum* he described an appendix, "not unlike a worm coiled in a circle." He reproduced the illustrations of Vesalius. Tulpian in 1641 gave an illustration showing the vermiform appendix, and followed the

teaching of Vesalius in calling it the "cæcum," while he termed the caput coli the "colon."

Fabricius ab Aquapendente likewise described the human cæcum as very small, as if it were an appendix, oblong and very narrow, rivaling a worm in appearance; at autopsy, he added, he had at times found a worm in it. This appendix, which he called cæcum, he said was bound by folds of membrane to the sides of the ilium (*sic*), and its chief function (*loc. cit.*, f. 147) he thought to be to hold the caput coli in place, as a ligament. He discussed in some detail the cæcum of animals, of birds and of fishes, and recognized from comparative anatomy that man's appendix takes the place of the lower end of the cæcum, which in man is not nearly so capacious as in the lower animals that have no appendix.

Morgagni, in his "Adversaria Anatomia," first published in 1706, devoted considerable space to an account of the vermiform appendix. He said that hitherto it had been considered to exercise one of two functions, either to receive something from, or to give something to, the intestinal tract. The former function Morgagni believed to be impossible because of the size of the appendix and the condition of its lumen and its orifice. As an instance in support of his views, he quoted the observation of Zambeccarius, who, although he cut off a portion of the appendix of a puppy-dog, ligating it, yet after three months found the base of the appendix clearly open, and yet no fecal matter had fallen from it into the abdominal cavity. Morgagni asserted that the appendix does not hang down from the cæcum, but, as it were, empties itself down into the cæcum. Of ten cadavers which he examined in only two did the appendix open into the middle of the base of the cæcum; in the eight others the orifice was to the left, between the base of the cæcum and the ileo-cæcal valve. In two other cases he observed that the appendix even pointed perpendicularly upward, one being without any curvature closely applied to the cæcum. He gave good illustrations of the cæcum and appendix.

Verheyen gave "appendix vermiformis" as a marginal heading in his work on anatomy published in 1710. He said there was much dispute as to the application of the word cæcum, whether it should be used with reference to the caput coli, as was done by the ancients, or to the appendix, as we have seen was first done in 1543 by Vesalius.

Verheyen sided with the ancient authors, in favor of calling the *caput coli* the *cæcum*.

Santorini in 1724 wrote of having seen the appendix lying directly upward between the *psoas* muscle and the hollow of the liver. At autopsies he had also observed *fæcal* concretions and worms in the appendix, and had in one instance found the appendix absent. He noted the appearance of a *meso-appendix*, and thought the chief function of the appendix was to serve as a nest for round worms, where they might be cherished, and be prevented from escaping into the general intestinal tract.

Lieberkühn's essay, which appeared in 1739, is looked upon as a classic in this department of literature. He remarked that he could understand readily from its construction that some have asserted, while others have denied, that *fæcal* matter, when the appendix is wounded, escaped into the abdomen. Referring to the experience of Zambeccari, as reported by Morgagni, he said, "This I have also observed myself, but of several dogs not even one lived till the next day after the operation."

Vosse in 1749 appears to have been the first to recognize the part played by the various pockets of the *peritoneum* around the *cæcum* in concealing the appendix from view. He said that sometimes the appendix hides beneath the *cæcum*, and hence is not found. He also observed some cases in which the *cæcal* orifice of the appendix was the narrowest part of its lumen, and in three out of six cadavers he noted that the orifice was occluded by a fold of mucous membrane. Weitbrecht, who died in 1747, also said he observed a valve at the *cæcal* orifice of the appendix. Haller in 1778 stated that in the *foetus* the appendix is relatively larger than in the adult—often half the size of the *ileum*.

Sabatier in 1781 called attention to the large number of mucous glands in the appendix, but added nothing new to the knowledge of its anatomy.

Since the close of the eighteenth century the gross anatomy of the appendix has been fairly well known: its three coats; its mucous glands, and their abundant secretion; the *meso-appendix*, and the folds produced by the *peritoneum* in this region—these were discussed in more or less detail by all anatomical writers during the early part of the nineteenth century. In the succeeding

decades, among an innumerable number of articles on this phase of the subject, a few stand out as of preeminent importance. Gerlach in 1847 called renewed attention to the fold of mucous membrane which may act as a valve in occluding the orifice of the appendix, and which has since gone by his name; and in 1859 he still further discussed the anatomy of this organ.

Treitz in 1857 described the peri-cæcal fossæ, but no adequate account of these folds of peritoneum appeared until 1891, when Lockwood and Rolleston published their elaborate studies, while Clado, in the next year, in an exhaustive article, aroused interest in a fold of peritoneum running from the ovary to the meso-appendix, and since known under his name, as Clado's ligament.

The minute anatomy of the appendix has not received attention until comparatively recent years, some of the best studies being those of Lockwood.

CLINICAL DATA.

"Suppuration upon a protracted pain of the parts about the bowels is bad." This aphorism of Hippocrates forms practically the first recorded observation of a disease known for centuries subsequently under the rather vague name of the iliac or the colic passion. Its cause was not understood, but it was explained, in a manner more or less satisfactory to themselves, by the various authors of classic times. Another aphorism of Hippocrates records the fact that from the rupture of an internal abscess prostration of strength, vomiting, and *deliquium animi* result. That some of these cases seen by the Father of Medicine were instances of appendicular abscess is scarcely for a moment to be doubted. That many of them were other affections seems even more certain.

Celsus, who lived in the latter part of the first century B.C., and in the early part of the first century of our era, distinguished between the colic passion, situated in the large intestines (and therefore, according to him, below the umbilicus), and the iliac passion, an affection afflicting the small bowel exclusively, and therefore having its seat entirely above the navel. These two terms, iliac and colic passion, were used by medical writers until well toward the end of the eighteenth century, without there being made any very

great distinction between the two, either as regards causation, symptoms or treatment; and what at one period were considered rather indicative of the colic passion were symptoms at another time attributed to the other. Celsus made the clinical observation that the colic passion was more often on the right of the abdomen, near the cæcum, than on the left; and he also noted that it was very apt to recur. Aretæus, who is believed to have lived about one hundred years later, considered death from the pain alone, in cases of the iliac passion, quite possible, even before local lesions had formed; while, he added, some survive the pain only to die of suppuration or gangrene of the bowels.

Galen, writing in the close of the second century A.D., said the iliac passion was an inflammation of the intestines, so that neither flatus nor fæcal matters can pass through; "violent gripes follow, and intolerable pains." Oribasius, a medical writer of the fourth century, although his complete works were not published until 1858, asserted that ileus was due only to inflammations, and that the lumen of the bowels may or may not be obstructed, according to the seat of the lesion and its severity. If the inflammation arises high in the intestinal tract, obstruction is not complete, but if the large bowel is affected the obstruction is complete. He recognized the formation of peritoneal abscesses, but added nothing new.

None of these writers paid much attention to differential diagnosis, although they recognized that symptoms such as these might be caused by volvulus, intussusception, strangulated hernia, and other pathological conditions.

The Arabian school of medicine, which forms the bridge between the classic and the mediæval, is fairly represented by Avicenna, who flourished in the eleventh century. He made the usual distinction between the colic and iliac passions, but contented himself with saying that the causes of both were the same, although the symptoms of the iliac were more severe, and required more strenuous treatment. He considered it a good sign if the pain shift, a bad sign if it remain in one place, or if an abscess form. The occurrence of this last complication might be suspected if the pain, having become fixed in one place, became of a throbbing character, with a feeling of weight, pulsation, and inflammation, with acute fever, redness and swelling.

Among the earliest of the mediæval writers is Arnaldus Vil-

lanovanus, who flourished about 1300 A.D. He added to the stereotyped description of this disease the opinion that one form of passion may turn into the other, or that both may exist at once. If the disease persists and becomes severe abscesses may form.

Fernelius recorded in 1567 a case of ileus, or iliac passion, from obstructed and narrowed "cæcum," in a girl nine years of age. This child had been suffering from a diarrhœa, and her grandmother, taking counsel "with other old women," decided to give her a quince, this fruit being known from the time of Dioscorides for its extreme astringency in the green state. As a consequence of this dose the diarrhœa was not only checked, but no passage from the bowels occurred at all that day and the following night: the most excruciating and agonizing pains arose in the abdomen, which swelled up in a marvelous manner. A physician being now called in, and suspecting what the trouble was, endeavored, but in vain, to alleviate the child's sufferings, first by mild, and then by more active enemata, and by soothing abdominal applications. Finally the vomiting became stercoraceous in character, there were frequent periods of *deliquium animi*, and within two days a pitiable death ended the child's pain. At the autopsy the "cæcum" was found to have the interior of its "duct" narrowed and constricted by the remains of the quince, with the result that the "corrupt matter," being prohibited from its normal outlet ("meatus"), had made an unaccustomed way for itself, by perforating the intestine above the obstruction, and thus had filled the whole abdominal cavity. It is an interesting question whether Fernelius understood by the term "cæcum" the vermiform appendix, as did his contemporaries Vesalius and Fallopius, and as did even some fifty years later Tulpus. It is to be recollected that Paré said that most of the anatomists of his time understood the word cæcum as referring to the vermiform appendix. That this was the case with Fernelius seems probable when we consider the application of the words "duct" and "meatus," which do not seem particularly appropriate to the caput coli. Moreover, the scholia, by Simon Paulus, which follow this case where it is quoted in the "Sepulchretum" of Bonetus, are largely concerned with the function of the "cæcum intestinum," which is referred to as "that apophysis," a little appendix ("appendicula"), sewed on to the junction of the small and large intestine, and is

further described as having been taken from the bodies of still living dogs by the writer's son, John Henry Paul, who found that this "appendicula" was generally filled with fæcal matter, and often had in its lumen "little drops of its own kind of excrement, as yet unnamed by anatomists."

Reading then "appendix vermiformis" for "cæcum" in the above reported case, we evidently have an instance of appendicitis, which is the earliest thus far known. But even if we consider it as a case of appendicitis, it is evident from subsequent writers that the vermiform appendix was not for a long time afterward recognized as a cause of disease. Yet the works of Erastus, who published his commentary on Paracelsus in 1572, show a distinct advance in differential diagnosis. Paracelsus had taught that all colic pains came from flatus, whereas Erastus himself said very distinctly that some of these cases were due to inflammations, and that the variety so arising was more difficult to cure as well as of less frequent occurrence. The colic pains arising from inflammation became fixed to one place, and by this fact, together with the presence of bilious vomiting, thirst, fever and wakefulness, the more serious disease might be distinguished from that due only to wind.

In 1612 Peter Lowe treated briefly of the iliac passion, and gave the interesting information, on the authority of Lonicerius, that "Hippocrates did die of this disease." Lowe did not even mention the appendix in this connection. Fabricius ab Aquapendente (1634) described both the colic and the iliac passion, the causes and signs of both being the same in kind, but those of the iliac much worse in degree. His account is in every way inferior to that of his contemporary Fabricius Hildanus, who often made autopsies in those who had died of the iliac passion, and always found lesions around the ileo-cæcal region. He thought, however, that the affection originated as an inflammation of the ileo-cæcal valve, which thus caused intestinal obstruction by swelling and occluding the lumen of the bowels. Most of these cadavers, he ingenuously added, smelt so horribly that he was not very minute in his examination.

Saracenus in 1642, in a letter to a medical friend, gave the details of a case occurring in a woman of fifty years, which he thought sufficiently curious to be thus recorded. There arose in her right groin a swelling, which at length suppurated, and finally pointed and

broke externally, discharging for a long time pus of a filthy odor. As gangrene of the parts seemed imminent, the physician in charge of the case applied an escharotic ointment. Soon after this the sinus began to discharge half-digested food and faecal matters from day to day; so that it was easy to recognize in the discharge whatever the patient had eaten shortly before, especially such matters as dried plums. After awhile six lumbricoid worms were discharged. From all these symptoms Saracenus concluded that a lesion of the large intestines was indisputable. It was not until she had reached this stage of the disease that Saracenus saw her himself, but with his own eyes he beheld eight worms discharged from the faecal fistula at various times. By degrees the ulcer contracted, the faecal discharge became less, and the patient returned to good health, although Saracenus expressed the anticipation that a return of her trouble was to be apprehended. He told his friend that he would advise him of the further progress of the case; also that he was under the impression that he had seen a similar case described somewhere, but could not recall the author's name. Unfortunately Roussel, who first published this letter, fails to inform us where he discovered the original epistle of Saracenus, nor does he say whether Saracenus fulfilled his promise of recording the patient's subsequent history. However this may be, there can be little doubt in any one's mind that this is the earliest known example of recovery from a peri-appendicular abscess.

Helmont said (1664) that all abdominal pains were from flatus, and that all obstructions may be removed by swallowing lead bullets. He did not mention the appendix, nor did he speak of inflammation as a cause of the iliac passion. Two years later, in 1666, Sydenham made the important clinical observation that in the commencement of this disease the pain is less fixed than it becomes later, when it is wont to settle to one spot, and remain there. It is true that Avicenna recognized the fact that the pain at times—when an abscess forms—becomes fixed to one spot; but it seems that Sydenham was the first to lay stress on this localization of the symptoms as one of the most valuable diagnostic points; in fact, he seems to have had an inkling that these symptoms arose from a disease that was distinct in its causation from volvulus, strangulated hernia, intussusception, and all other intra-abdominal affections. Erastus, to be

sure, nearly a hundred years before Sydenham, had noted that the pain became fixed in all inflammatory diseases of the abdomen, but he does not appear to have been aware, as Sydenham apparently was, that there was one disease especially characterized first by diffuse abdominal pain, and then by pain settling to the part of the abdomen affected, which disease was later proved to be appendicitis. As causes of this disease, Sydenham gave improper indulgence in the fruits of the season, or in any indigestible food. He remarked that the disease was prone to return after recovery.

In 1682 Thomas Willis wrote, "Inflammation or sphacelus about the beginning of the colon, which I have often noted, arises from vain efforts to expel fæcal matters, which becoming stagnated against the ileum, produce the iliac passion." Baglivus (1696) added his testimony to the usual symptoms of this malady, by stating that when a colic pain becomes fixed, and a fever supervenes, it is accustomed to terminate in abscess; not so if the pain shifts from place to place.

Boerhave, who first published his "Aphorisms" in 1709, graphically described the course of events in this disease somewhat as follows: Inflammation of the bowels produces an obstruction, which causes an ardent fixed pain; vomiting ensues, and an iliac passion is formed, whence an abscess or gangrene may arise; then follows "a most sharp fever, and extreme weakness, from the violent pains, which next close by a speedy death." He added a caution to the attending physician which is not without its value at the present day: "As long as this malady continues in its inflammatory stage, it often imposes upon those who are incautious under the name of a colicky pain, by whom it is, with the most dangerous events, ascribed to cold, to wind, or to flatulencies, and accordingly ill-treated by carminative and hot medicines, with the most fatal consequences." If he be not cured, either an abscess will form, and rupture into the bowels, with recovery, or into the abdominal cavity, with death; or else gangrene will occur, and a quiet death speedily ensue.

Santorini in 1724 wrote of having observed fæcal concretions as well as worms in the appendix at autopsies.

Ruyschius, his contemporary, tried to differentiate the various causes of the iliac passion, but did not mention the appendix.

In 1735 Amyand operated on an inguinal hernia in which he

found the perforated vermiform process. This case will be more fully discussed under the head of Treatment.

Crellius in 1752 published notes of an autopsy, in which he described a peculiar vermiform appendix which he found in a woman. This appendix was not only larger and more capacious than is usual in adults, but was filled with a compact substance. On opening the caput coli he found the cæcal orifice of the appendix unusually large, admitting with ease the tip of the little finger, and its lumen filled with fæcal matter in the form of little globules. This phenomenon he thought supported the theory of those who maintain that the function of the appendix was to serve during intra-uterine life as a receptacle for the fæces, inasmuch as in the present case he found on further search that the descending colon was constricted to the size of the small bowel, while the ascending and transverse portions of the colon were remarkably dilated.

Heister in 1753 published the details of a case in which he had made an autopsy as early as 1711. In the abdomen of a malefactor he found the vermiform process gangrenous and lying in a small collection of pus, among adhesions. This proves, said Heister, that this part can be the seat of inflammation and abscess as well as other parts; a fact which he thought had not been sufficiently noted before. And if we reject the case of Fernelius, cited above, this case of Heister's is undoubtedly the first instance known in which the lesions are positively stated to be in the appendix. For the case recorded by Saracenus is merely one of fæcal fistula following suppuration in the right iliac region, the patient not coming to autopsy, so far as we know, and the appendix not being mentioned in any way.

In 1755 Wedels recorded a recurrent attack of iliac passion which had been observed in 1670. The patient experienced sudden, causeless pain in the right iliac region, similar in character to that occurring one year before; there was fever and vomiting, with local tenderness, and a mass was palpable. The affection was rebellious to clysters, but the patient recovered on the third day, after a dose of opium. In the same year Garmanns saw a woman who had an abscess over the region of the cæcum which was opened by poultices, and discharged many round worms. This patient also recovered.

In 1759, four years after the publication of these cases, Mestivier

reported a fatal case of abscess on the right side of the umbilicus, found at the postmortem examination to be due to the perforation of the appendix by a pin.

In 1766 de Lamotte found, at an autopsy on a man who died after acute abdominal pains, intestinal obstruction and peritonitis, that the appendix was much enlarged, and contained a large concretion the size of an orange, but resembling a potato in appearance, though more spherical. This concretion weighed four ounces. Although there was no perforation he recognized the appendix as the cause of the disease.

In 1768 Herlin discussed the function of the appendix, stating that in 1734 M. Delatoison made an autopsy on a man-servant who had died of the iliac passion, and who had been made to swallow three large balls (in hope of overcoming the obstruction). These were found in the appendix, which was dilated by fæcal matters nearly to the size of the rest of the gut.

In 1778 Haller wrote that he had twice seen the lumen of the appendix obliterated; and that, wonderful as it may seem, it had been possible to remove the appendix without harm not alone from hens, but even from man and dogs. "*Mirum videri possit, potuisse non gallinis solis, sed homini (hernioso Zambeccari apud Fantonum) sed canibus ipsis, absque noxa absecari.*" The reference to the ruptured patient of Zambeccarius, as quoted by Fantonus, it has been impossible to find.

In 1794 Baillie in describing the pathological anatomy of the vermiform process said that he had seen it varying from as long as five inches to scarcely a half inch long; that he had noted its presence in a congenital hernia, lying close to the testicle; had seen its canal obliterated; and had found both worms and earthy concretions in it.

In 1808 Jadelot observed the case of a boy, which clinically showed only fever of an adynamic type. At the autopsy lumbricoid worms were found in the ileum, cæcum, and appendix.

In 1812 Parkinson saw a young man who was ill for two days with abdominal symptoms. At the autopsy he found the distal one inch only of the appendix swollen and inflamed, and perforated. Nearer the base of the organ was a fæcal concretion impacted in the lumen. The cæcum and other viscera were normal except for the peritonitis. Copeland was more fortunate in a case which he

observed the same year: a faecal abscess developing in the right groin was opened by poultices; some weeks later an oval calculus, a half inch long, was removed from the sinus with forceps. The faecal discharge lessened, and complete cure resulted.

In 1813 Wegeler recorded the case of a youth of eighteen, who, after a fit of anger, drank a quantity of ice-water. Soon he experienced excruciating abdominal pains in the right iliac region, well localized. Persistent bilious vomiting developed, which after twelve hours became stercoraceous. Wegeler diagnosed "that well known obscure form of enteritis, later turning into ileus, as an effect, not a cause." At autopsy the cæcum was found destroyed by gangrene, which evidently had arisen from the base of the appendix. This process itself, of an even more intensely red color was larger than usual, and its mesentery injected. It contained many calculi. Wegeler was very far, he said, from thinking these calculi were the origin of the disease; but he could very readily be led to believe that an inflammation arising elsewhere would rather attack a part so affected than some other region, and thus the severity of the disease be markedly increased.

In 1815 is found what is apparently the first American case to have been reported. Prescott narrated that his patient had had pain in the right iliac region for about one year, when he was suddenly attacked with a very severe pain in this region, and died on the fifth day, after symptoms of general peritonitis had developed. The autopsy showed the cæcum with the neighboring parts of the colon and ileum sphacelated, and the cæcal orifice of the appendicula vermiformis obstructed by a cocoa or chocolate nut, which was recognized as the cause of the disease. Prescott says that he is not familiar with any similar case, but suggests foreign bodies in the appendix as a cause for many symptoms arising in the right iliac region.

In 1824 Louyer-Willermay recorded two fatal cases of peritonitis due directly to perforation of the appendix; and Blackadder a case in which death occurred about three hours after the onset of acute abdominal symptoms, with a semi-comatose condition of the patient. The autopsy in Blackadder's case disclosed as the only abdominal lesion the vermiform appendix immensely distended by a huge lumbricoid worm, but with no perforation. The heart was

the seat of long standing disease. Blackadder said he had also observed faecal concretions in the appendix, and called attention to this fact in connection with the operation recently proposed by Monro for the purpose of removing such concretions from the cæcum by the extra-peritoneal route. No one, however, appears to have followed this suggestion until 1883, when Symonds, at the instance of Mahomed, successfully extracted a calculus from the appendix, in the manner described by Blackadder.

In 1827 Husson and Dance at the suggestion of Dupuytren, who later published his own views, discussed diseases of the cæcum at considerable length. They held that as a rule the retro-peritoneal cellular tissue was first involved in these cases, but that in rare instances the peritoneum itself was first inflamed, the disease attacking the cellular tissue only at a later date. If the abscess formed were intra-peritoneal, and this they thought was always the case unless the cellular tissue were first attacked, then its rupture into the bowels was very rare, these cases usually terminating by general peritonitis and death. Some cases they had observed as long as nine and even sixteen years ago, the patients having recovered after rupture of the abscess into the bowels, and having had no return of symptoms since.

Méliér in this year made a further advance in describing diseases of the appendix with considerable accuracy, believing them to be entirely distinct from cæcal trouble. He even went so far as to say: "If it were possible to establish with certainty the diagnosis of this affection, we could see the possibility of curing the patient by operation. We will, perhaps, some day arrive at this result." This brilliant article of Méliér's appears to have fallen upon barren ground. Most of his contemporaries do not even mention it. Yet it is by all means the most important contribution to the literature of appendicitis prior to the well-known article by Fitz, in 1886. For lucidity of opinion, and near approach to modern teaching it is probably unexcelled.

In 1827 also Wickham reported a fatal case of perforated appendix in a boy, two calculi being found in the appendix.

In 1828 Menière collected thirteen cases of acute phlegmonous tumors in the right iliac fossa, and reviewed three such cases already reported by Husson and Dance. He considered all such cases to

be due to retro-cæcal cellulitis. He reported also chronic cases (*loc. cit.*, p. 532), saying that in one case he had observed the appendix acquire a circumference of more than four inches, thus making one believe in the existence of cancer of the cæcum. Ponceau, he said, reported three examples of these affections of the right iliac fossa.

It is interesting to note that Jobert, in a work devoted exclusively to the surgical affections of the intestinal canal, published in 1829, did not even mention the appendix in his description of the anatomy of the parts, nor did he refer to any lesions to which it might give rise.

In 1830 Goldbeck, at the suggestion of Puchelt of Heidelberg, chose this disease as the subject of his graduation thesis. Following the recent French writers, he considered two distinct affections, one involving the appendix, and the other, perityphlitis, as quite distinct; he stated that in fatal cases of this latter affection the appendix had been found intact. Bodey, in his Paris thesis of this same year, noted that he had seen five cases of perforation of the appendix, in all of which general peritonitis was for a time prevented by the formation of adhesions, which finally being broken through, allowed death from fæcal extravasation. He gave the details of two cases.

In 1831 Waldron reported a fatal case of perforated appendix, with a concretion; and Ferrall published a monograph, in which he adhered to the view that in phlegmonous tumors of the right iliac fossa the cæcum is the organ primarily involved, and that the retro-cæcal connective tissue is a more important factor in the subsequent course of the case than is either the appendix or the peritoneum. Tumors in the right iliac fossa he thought might be classified advantageously under three heads: (1) Fæcal impaction, without inflammation. (2) Malignant tumor of the cæcum. (3) True phlegmonous or inflammatory masses, proceeding from irritation of the mucous membrane of the cæcum, or from ulceration and perforation of its wall.

In 1832 Iliff reported three fatal cases as follows: in the first, death occurred from a general purulent peritonitis, caused by a foreign body which had ulcerated, but not perforated the vermiform process; in the second, a bean was found in the appendix at autopsy; while in the third, although the pain during life was chiefly on the

left side of the abdomen, yet the postmortem examination showed a calculus lodged in the appendix.

In 1833 Dupuytren published the views which he had been teaching for some years. He asserted that these abscesses in the right iliac region were developed around the cæcum outside of the peritoneum, but were capable of causing inflammation in this membrane. As the most trustworthy symptoms he recognized pain, resistance, tension, with a palpable mass developing after a time, and tenderness. He thought that abscesses opening through the abdominal wall were nearly always fatal, because drainage was so difficult. Of sixteen cases of abscess, with which he was familiar, only one died. He did not mention the appendix in this article, but in the second edition of his "*Leçons Orales*," published in 1839, he reported a case of perforation of the appendix already recorded by Menière, in which the cæcum and the surrounding parts had "returned" to their normal state, while the appendix, nearly disorganized, communicated with an abscess cavity between the anterior abdominal wall and the parietal peritoneum. Dupuytren added that inflammations and diseases of the appendix, of which he had seen a fairly large number, had not fixed the attention of authors, but that Mélier had written an excellent article on this subject. Although Dupuytren reported several similar cases, in none other did he recognize the appendix as the true seat of the disease; and it is probably in large measure due to his teachings that an appreciation of the real state of affairs slumbered, in the minds of a few observers only, for the next fifty years.

In 1834 Boyer noted a death following perforation of the ileo-cæcal valve. Petrequin considered this absurd, and called it a case of perforated appendix. The original report obscures the true condition by inaccuracy of expression and typographical errors.

In 1834 Copland entered upon a study of the diseases of the cæcum in greater detail, and pointed out that inflammation of the appendix might give rise to very serious affections in the cæcal region. He further mentioned "mortification" of the appendix from the lodgment of a foreign body, and said that this might be followed by fatal peritonitis, but did not consider inflammation of the appendix ever a cause of localized suppuration.

In the year 1835 the most important contribution to the subject

was a further article from the pen of Louyer-Willermay, who referred again to his earlier cases (1824), and insisted on the appendix as the cause of the disease. He claimed for himself the priority in noting this fact. Ahrt in the same year reported a case in Berlin, in which he had opened an abscess over the cæcum, which he thought the cause of the disease. He did not mention the appendix. Pierou also reported cases: the first fatal from perforation of the appendix; and the second in a patient who suffered from symptoms of intestinal obstruction in the right iliac region, ending in recovery, after an abscess had pointed in the right ischiatic region. This latter case he diagnosed as one of appendiceal perforation.

In 1836 von Merling published an extremely important monograph on the pathological anatomy of the vermiform process. He gives a very complete review of the cases of diseased appendices hitherto reported, and discusses their lesions under the following heads: (1) Absence of the appendix. (2) Obliteration of its canal. (3) Length and size. (4) Displacements. (5) Adhesions. (6) Foreign bodies. (7) Inflammation without foreign bodies. (8) Ulcerations. In discussing the influence of foreign bodies he recognized two classes of cases: first, those in which no symptoms were present during life, the offending substances being found only postmortem; and second, those in which the foreign body evidently caused death by the inflammation which it produced. Under the seventh heading he recorded two cases now reported for the first time: the first, observed by Tiedemann, consisted in cystic degeneration of the appendix, the cæcal opening having become obliterated; the second, observed by Hoffacker, was in the person of a young student, in whom, after death from abdominal disease, the autopsy showed inflammation starting in the cæcum and colon, and extending to the appendix, which was mostly destroyed. Hoffacker's opinion was, says Merling, that an abscess had first arisen, and had subsequently destroyed the cæcum and appendix. Another case here reported was that of an appendix found at autopsy adherent to the large bowel on the left of the abdomen, a probe passing from the cæcum, through the appendix, into the large intestine. The only instances of ulceration of the appendix without perforation noticed by Merling were two previously reported, where the affection was recognized as tuberculous.

Another important paper on diseases of the cæcum and vermiform appendix appeared in 1837 in England. This was by Burne, who maintained the still prevailing view that most affections in the right iliac fossa, of which he had seen some twenty examples, were due to primary involvement of the cæcum. He reported eight cases, in only three of which did he think the appendix at fault. The cause, he added, was not idiopathic, in any such cases, but generally due to the lodgment in the cæcum of indigestible food. The most reliable symptoms, he held, were pain and exquisite tenderness. About the fifth or sixth day the "turn" of the case occurred, whereupon either recovery ensued, or an abscess formed. In the appendix cases he called attention to the importance of the position of the appendix in determining the position of the abscess. Slight ulcerations of the appendix from foreign bodies were often found, he said, and caused no particular inconvenience; but if the foreign body should become impacted, gangrene from pressure, followed by perforation, would ensue. In accord with the views of those days in regard to the pathology of inflammation, he asserted that even with ulceration no inflammation arises until the peritoneum is involved, when an abscess will result from local inflammation, or general peritonitis if the inflammation spreads. Two years later Burne wrote a second paper, in which he maintained that the cæcum was of comparatively little importance in affections of the right iliac region. He thought that practically all cases of cæcal inflammation recover, and that where perforation took place in the cæcum it was always to be attributed to the existence of disease previous to the acute attack which appears to be the cause of death. Thus if perforation of the cæcum occurred from within he held that it was due to tubercular or other ulceration; whereas if it occurred from the outer surface it would be caused by disease of the adjacent vermiform appendix. He reported several new cases, the most interesting being one of "sero-enteritis arising in the peritoneal tunic of the appendix," in which the lumen of the appendix was pervious, and the mucous membrane not diseased, but the coats were much thickened, and local peritonitis was present, with serous exudation and many adhesions. His conclusions were that of affections in the right iliac fossa those of the cæcum were most frequent and least serious; that perforation of the appendix held second place; perforation of the cæcum coming

third; while very rare indeed was inflammation of the appendix without perforation.

While there was nothing particularly new in these papers of Burne, they mark one more authority ranking himself on the side which was constantly gaining recruits, that which recognized the existence of two distinct diseases in the right iliac region, the more serious of which had the vermiform process as its cause.

In 1837, also, cases of perforated appendix were reported by Von Pommer Esche and by Corbin, the latter's patient being a phthisical man, and the lesion of the appendix probably tuberculous. Both patients died. Petrequin, in this year contributed an article in which he noted the function of the omentum in covering in the appendix and localizing abscesses.

In 1838 Albers noted the possibility of the occurrence of disease in the right iliac fossa as the result of inflammation of the vermiform process, but thought that it more often arose in the cæcum. Under the name of "typhlitis" he described four distinct affections:

1. Stercoral typhlitis—irritation from faecal matter.
2. Simple typhlitis—catarrhal inflammation from any cause.
3. Perityphlitis—extension of the disease from the mucous lining of the bowel to its serous coat and the surrounding tissues.
4. Chronic typhlitis—in which the course of the disease was slow and prolonged.

When pus formed and a perforated appendix was found, he considered that the perforation was due to the previous formation of pus.

In 1838 another tuberculous perforation of the appendix was recorded by Hallowell, producing death in about twelve hours from suppurative peritonitis. Hornung also reported a fatal case of perforated appendix.

Grisolle, in 1839 collected in all seventy-three cases of phlegmon in the right iliac fossa, and recognizes perforation of the cæcum or its appendix as an occasional cause of this affection.

From this date on the reported cases of perforation or other disease of the vermiform process become so numerous, that mere mention of all would be impracticable in a work of this kind; therefore all that will be attempted will be a reference to the more im-

portant articles, with passing comment on any advances that appear to have been made in the pathology or diagnosis of such affections.

Rokitansky is remembered for having first called marked attention to catarrhal inflammations of the appendix. In his "Hand-book of Pathological Anatomy," published at Vienna from 1841 to 1846, he described diseases of the vermiform appendix in the following words: "Catarrhal inflammation of the vermicular process is a disease of common occurrence, and very dangerous on account of its consequences. It much resembles typhlitis stercoralis, and is invariably the result of fæcal matters and foreign bodies, especially small fruit stones, having become lodged and hardened in it. The affection has a torpid character, may exist for a long time as blenorrhœa, and is accompanied by thickening of the coat of the vermicular process. After frequent exacerbations it passes into ulceration, which may, if the foreign body remains loose, attack the entire process, or if the former becomes fixed, affect only the point of attachment, or the end of the vermicular process. Under favorable circumstances the vermicular process shrivels up and forms a ligamentous appendix. In the opposite case the ulceration brings on perforation. This is not immediately followed by general peritonitis, inasmuch as the previous irritation has induced adhesions. The adhesions gradually give way, and general peritonitis ensues." Rokitansky had observed also cystic degeneration of the appendix, as well as typhoid and tuberculous ulcers causing perforation.

Another good article on the diagnosis and pathology of diseases of the appendix is the editorial in the *Archives Générales de Médecine*, for 1841, in which are included reports of cases by Malespine and by Briquet; the editors reviewed also the articles of Burne, Petrequin, Merling, Grisolle, and others, and apparently recognized the following forms of disease:

1. Peri-appendicular non-suppurative inflammation, which may resolve without pus-formation.
2. Peri-appendicular abscesses, which may terminate by rupture either into the bowels or intra-peritoneally; or may be opened externally.

3. General peritonitis from perforation of the appendix, without any attempt at localization of the process.

As ætiological factors they recognized: (1) Foreign bodies and faecal concretions. (2) Tuberculous or other ulcerations. (3) Some undefined causes producing inflammation without perforation.

In 1843 Volz published an essay in which he upheld the rather unpopular view that the appendix was responsible for more of the affections of the right iliac fossa than was the cæcum. He reported five cases, and in the first four the diagnosis was confirmed by autopsy, but although his fifth patient recovered he was sure the lesion had been a perforation of the appendix. The symptoms on which he placed most reliance were abdominal pain, which soon became localized to the region affected, and local tenderness. He thought there was not apt to be any fever, and that the pulse rate usually was not accelerated. In this stage of the disease recovery might occur, or on the other hand general peritonitis might supervene, with diffused pain and tenderness, tympanites, intestinal obstruction, small fast pulse, cold extremities and death.

In 1846 Ormerod, although he described several cases of right iliac abscesses, yet made no mention whatever of the appendix; which shows that even at this comparatively late date the cause of the appendix was far from being won.

In 1847 Walther said that the catarrhal form of the disease was more severe than that due to foreign bodies, although he thought that perforation was only possible when these were present. He expressed the belief that concretions form in the cæcum, and ultimately press aside the valve of the appendix, and enter its lumen. Cless in 1847 diagnosed a perforation of the appendix, which was confirmed by the autopsy.

Oppolzer, in 1858, made a further advance in the pathology of inflammations of the appendix, when he divided iliac phlegmons into: (1) Extra-peritoneal, and (2) Intra-peritoneal. He thought that inflammation of the appendix must produce the latter variety.

In 1859 Leudet abandoned the idea that inflammation of the right iliac region arose in the cæcum, and contended that perforation of the appendix was more common than perforation of all other parts of the intestine combined; and noted that such perforation may open into the cæcum, rectum, vagina or bladder, or through the

abdominal wall. He also considered some cases of abscess of the liver and pylephlebitis as dependent upon this disease. He considered localized suppuration a more common result of perforation of the appendix than general peritonitis.

In 1867 Dr. Wm. Pepper noted the cure of an old lesion of the appendix by conversion of the organ into a fibrous cord.

In 1875 Wilks and Moxon stated that the appendix usually was at fault in these troubles, but still considered that inflammation of the cæcum, with perforation producing abscess and peritonitis, did sometimes occur, although they expressed the opinion that in severe cases the appendix was the seat of disease. They moreover recognized the fact that perforation was not always necessary to produce suppurative peritonitis.

In 1880 Bierhoff gave a very complete account of the pathology of the appendix, though he made no marked advance from the teachings of Merling, in 1836. As causes he gave, besides foreign bodies or concretions, and a catarrh which forms part of a general intestinal inflammation: (1) Other acute diseases, as typhoid fever, dysentery, cholera, etc.; (2) neoplasms, as tuberculosis and carcinoma; and (3) parasites, of which the *Ascaris lumbricoides* is the most frequent. A more important contribution in this same year is that of Matterstock who showed that of 146 autopsies in adults with peri-cæcal suppurations, in no less than 132 was the appendix perforated, while among 49 autopsies in children with perityphlitis, this organ was found perforated in 37 cases. But With, of Copenhagen, was probably the first to deny outright that typhlitis could ever itself give rise to peritonitis. He called the disease "peritonitis appendicularis," and recognized three forms: (1) Peritonitis appendicularis universalis. (2) Peritonitis appendicularis localis. (3) Peritonitis appendicularis adhæsiva.

In 1885 Fox first proposed the theory that perityphlitis was strictly analogous to quinsy, an inflammation in the peritonsillar tissues, being led to this idea from a consideration of the resemblance in structure of the appendix and the tonsil, both being very rich in lymphoid tissue; and also because he recognized the fact that in less than half the cases of inflammation of the appendix could foreign bodies be held accountable.

Reginald H. Fitz, beginning in 1886, in a memorable article

X

published in the American Journal of the Medical Sciences, gave an impetus to the study of affections of the vermiform appendix such as it had never before received, and by showing that the symptoms in 209 cases of typhlitis or perityphlitis were identical with those observed in 257 cases of perforation of the appendix, convinced the medical world of the practical truth of the contention that in all inflammations of the right iliac fossa the "fons et origo mali" was the vermiform process of the cæcum. It seems that in this article the term "appendicitis" is first used; and though many physicians objected to it as "a rather barbarous word," or as "an excessively clumsy term," yet its convenience was recognized by all, and it soon displaced all competitors, such as "apophysitis," "ecphyaditis," "epityphlitis," and "scolecoiditis." Whatever may be said in favor of these various terms, the last of which has greatest claims to consideration on philological grounds (*σκόληξ*, *lumbricus*, a worm), the word appendicitis, so widely in use in America, England, France, and wherever the languages of these countries are spoken, cannot be dropped, even were it desirable to do so.

For a number of years after the publication of these articles by Fitz, there were still a few isolated physicians who maintained that there were two distinct diseases met with in the right iliac region, typhlitis and appendicitis; but few if any asserted that the latter was the less frequent of the two.

The greatest of all advances in the diagnosis of appendicitis was that accomplished by McBurney when he described a point one and a half to two inches from the anterior superior iliac spine on a line drawn thence to the umbilicus, as the spot where localized pain and tenderness were almost invariably found in cases of inflammation of the appendix, this being the usual situation of the base of that organ. It was a valuable advance not so much because the pain is in every case just at that spot, but because it put into the physician's or the surgeon's thoughts, in a practical, concrete way, a ready method of excluding nearly every other disease with almost absolute certainty; and though it is not possible to deny the existence of appendicitis when pain and tenderness are in another place, it is a very rare thing for the signs to be circumscribed in this way and for the affection to be other than appendicitis.

The bacteriology of the appendix next claimed the attention

of writers and we find among the first to make such reports of their cases Goullioud and Adenot in 1891.

In 1894 Senn published an article on "Appendicitis Obliterans," but for next ten to fifteen years the chief subject of discussion was the treatment, the pathology and diagnosis having become more or less firmly established. This was so because operations constantly were being undertaken at an earlier date. By this means it has been shown that foreign bodies play a comparatively insignificant rôle in the causation of appendicitis, that perforation is by no means the only way in which peritonitis can arise, and that an appendix once the seat of inflammation never returns to its normal state, even if the patient can avoid a recurrence of the symptoms by careful diet and regularity of life.

TREATMENT.

To describe in any detail the various remedies recommended by the ancients for colic pains and ileus, would be neither suitable in a sketch such as this, nor particularly edifying. Suffice it to say that any surgical treatment was postponed until the last possible moment, when an abscess was actually pointing; and even in such a case the vast majority preferred to let the matter evacuate itself spontaneously, or to allow the patient to die a peaceful death without subjecting him to the discomfort of the abscess being opened at all, and without laying themselves open to the charge of having killed the patient by the operation. Yet that abdominal abscesses were occasionally incised, is proved by the instance cited by Aretæus in the second century. He opened an abscess "in the colon on the right side, near the liver, and much pus rushed out, and much also passed by the kidneys and bladder for several days, and the man recovered." It would be too much to assume that he was treating a case of appendicitis, which had ulcerated into the urinary tract, yet the possibility of this, among other greater probabilities, is not to be denied.

In the earlier stages of the disease, the course of treatment was somewhat as follows: Immediate venesection from the veins at the elbow, and, if retention of urine was present, from the saphenous vein at the ankle as well; blood being drawn in severe cases *ad*

deliquium animi. Emetics if the pain were above the navel; purgatives, however, should its chief intensity be below; but in cases where there was manifest inflammation, these remedies were not used, evacuation of the bowels being attempted by large and repeated enemata, forcefully injected. Sedatives were given sparingly, because it was thought that obstruction of the bowels was best overcome by purgatives, although they were administered only by enema, as above stated, in cases of inflammatory obstruction, the patient under such circumstances rejecting every medicine from the stomach by the prolonged vomiting. While sedatives were thus not given by mouth, they were directed to be applied locally; and the patient was made to sit in a bath of hot oil in which various drugs were dissolved. A very few of the ancient physicians caused their patients to swallow leaden pills, in the hope that by their weight they might force a way through all obstructions, and finally cause a satisfactory fæcal evacuation.

Later—in the time of Oribasius—it was customary to encourage the opening of an abscess into the bowels by hardening the overlying skin with astringents; and warm and emollient cataplasms were applied only when rupture externally appeared unavoidable. These same methods of treatment were pursued by the Arabian physicians with little change and practically no improvements.

In the time of Paré (sixteenth century), abscesses were opened without hesitation when they pointed externally; and great reliance was placed in the virtues of quicksilver to overcome intestinal obstruction. Thus Zacutus Lusitanicus informs us that Marianus Sanctus narrated that many were cured of the most deplorable iliac passions by drinking three pounds of quicksilver in hot water, "which even saved them from imminent death." It is curious to find this remedy still in use at as late a date as 1830. Pedrini, moreover, in 1883, reported three cases of "ileus" successfully treated by causing the patients to swallow five or six bullets and four pounds of No. 3 shot, at the same time using prolonged and repeated insufflation of air by the rectum.

Van Helmont, in 1664, boldly pronounced that no one can perish of the iliac passion if he do but swallow musket balls of lead, which by their superincumbent weight may drive forward the obstacle seated in the intestines; and that the larger these balls were, and

the greater the number of them swallowed, the more expeditiously would they be useful, especially if the patient could be kept upon his feet and walking about in an erect posture.

Sydenham's favorite application to the abdomen in these cases was the body of a freshly slain puppy-dog, slit open. In those cases where the pain returned after recovery, or where symptoms of abdominal discomfort persisted after an attack of the iliac passion, he recommended constant horseback riding, to jolt the noxious matters out of the cæcum, where they were prone to accumulate.

Riverius in 1668 narrated the following incredible case, quoted from Matthew de Gradi: A girl of twelve years was afflicted with the iliac passion, and reversed peristalsis became so strong, and fæcal vomiting so constant, that not only were ordinary suppositories vomited from the mouth shortly after being placed in the rectum, but even one tied by four strong threads to the thigh was drawn upward, the strings snapped, and the suppository, with parts of the threads still attached, shortly afterward rejected from the stomach. Besides giving the usual directions as to treatment Riverius laid great stress on abstinence, allowing only three spoonfuls of broth every day, for four or five days.

Boerhaave, the most learned of all medical writers, in 1709 advised the following treatment for cases such as these:

1. Large and repeated bloodlettings.
2. Laxative and cooling clysters, three, four, or more in a day.
3. Similar drinks, with a "prudent interposition of opiates."
4. Fomentations to the abdomen, more especially of living animals that are young and of sound health, split open and applied.
5. Avoiding all things that are acrid, forcing or heating.
6. Holding on in the same course until complete cure is assured, that is, until all symptoms have been absent for three days.

In 1735 is found the first authentic reference to the removal of the human appendix during life. Claudius Amyand, Esq., F. R. S., operated on a boy, eleven years of age, for the cure of a discharging sinus in the right thigh, which evidently communicated with an irreducible scrotal hernia. The hernia had existed from infancy, and for one month there had been discharged from this fistula "a great quantity of an unkindly matter." As it was evident that the cure of the sinus depended upon that of the hernia, "which

latter could be obtained by no other operation than that for the bubonocoele," this was agreed to, and the operation accordingly performed on the sixth day of December, 1735. "This operation proved the most complicated and perplexing Mr. A. ever met with, many unsuspected oddities and events concurring to make it as intricate as it proved laborious and difficult." The hernia was found to be chiefly omental, "the size of a small pippin," and in its interior lay the appendix cæci, which had been perforated by the point of a pin, whose head, covered with much incrustated stone, remained within the appendix, acting as a ball valve, and allowing at most unexpected and inopportune moments a copious discharge of faecal matter over the field of operation. The long standing inflammation had so knit together the sac of the hernia, the omentum, the appendix, and the testicle and cord, that their dissection was a most intricate and perplexing procedure. Besides all these adhesions, there was the additional difficulty of the sudden and overwhelming discharge of fæces, frequently occurring; the facts that the pin was continually getting in the way of the knife, that the exact whereabouts and form of the gut could not be detected, and that Mr. Amyand could not be sure how it ought to be treated until he could see it. However, the omentum was first dissected loose, cut off close to the abdominal muscles, and the stump allowed to retract into the adominal cavity without any ligatures, as there did not appear to be any good-sized vessels in it. Having completed this tedious dissection, the gut was next found, loosened from its adhesions, and the aperture from which fæces had all this while been escaping, at last detected. As the pin was withdrawn from the appendix a report was heard like that when a cork is drawn out of a bottle, so tightly did its enlarged head fit the lumen of the appendix. The bowel was now plainly seen to be the appendix cæci, and the consensus of opinion of the physicians and surgeons present was that it would be proper to amputate this gut. "To which end a circular ligature was made about the sound part of it, two inches above the aperture; and this, being cut off an inch below the ligature, was replaced in the abdomen, in such a manner than an artificial anus might be made there, if the patient's case should require it." Then the hernial sac was cut off, as high up as it had been possible to dissect it from the skin, spermatics, etc.; and these, as they appeared

in a sound state, were preserved *in situ*. The fistulous tract was pared, and its edges freshened, "the aperture in the (abdominal) muscles, which had been enlarged by incision, was stopped with a tent; and the rest of the dressings and the situation of the patient so ordered, as to remove from the wound all such pressure from within, as might disturb the cure." "It is easy to conceive that this operation was as painful to the patient as it was laborious to Mr. A.; it was a continued dissection, attended with danger on parts not well distinguished; it lasted near half an hour, during which the patient vomited largely, and had several stools, but was soon composed by 1/2 oz. of diacodium" (syrup of poppies) "and emollient embrocations and fomentations frequently applied warm on the belly; he was blooded, and an emollient carminative oily clyster was ordered to be applied in the evening; but as he was easy, and the belly not tense, that was omitted." On low diet, with an occasional enema, the case progressed favorably. First dressed on the fourth day, the tent was not removed until the eighth; the ligature dropped from the appendix on the tenth day, and no fæcal discharge followed it. The wound then healed uninterruptedly, care being taken to keep strong and constant pressure over it "as well to fence against the intrusion of the viscera into the wound, as by a strong incarnation and cicatrix, effectually to secure the patient against a rupture." The boy was discharged in good health, wearing a truss, in a little over a month from the date of the operation. Unfortunately, owing to neglect of proper use of the truss, a hernia again appeared, about six months later.

In 1757 Mestivier, as already noted in the previous section, saw the case of a woman, in whom a fæcal abscess, already fluctuating, and pointing to the right of the naval, was opened by the surgeon-major of the hospital. About one pint of pus, "of bad quality," was discharged; and although the patient did well for a time, she unexpectedly died when the resulting ulcer had nearly healed. This is the first concrete instance known of an abscess appendiceal in origin, as proved by the autopsy, being opened by incision; all previously reported cases having been allowed to burst of their own accord.

The medical treatment continued practically the same throughout the eighteenth century, and it was not until early in the nine-

teenth century that an advance in this direction was made, when, under the influence of the teachings of Graves and Stokes, of Dublin, opium in large doses was administered to all patients who presented evidences of peritonitis. This was an advance, we repeat, though it has happily been superseded by a still greater advance—early aseptic removal of the offending organ. It is true that Prescott and a few other practitioners, had employed opium in doses of six to eight grains daily, and apparently prolonged life by so doing; but their object was merely to allay pain, and the routine use of opium to put the bowels at rest, and by so doing to minimize the amount of faecal extravasation, and encourage the formation of adhesions, though employed as early as 1823 by Graves, was not the universal custom for some twenty years later. The good derived from the opium treatment was undeniable; it was the greatest good except the absolute removal of the inflamed appendix. It encouraged the formation of a localized suppuration (the only intra-abdominal complication successfully amenable to surgical treatment in those days), and even when this end was not attained, it rendered peaceful a death which without its use would have been a lingering agony of torture.

About this same time venesection was more or less completely abandoned for local bloodletting by leeches, which were applied to the seat of pain, and sometimes also to the perineum, in numbers of from thirty to sixty at once, several times daily.

Peri-cæcal abscesses, already pointing, are known to have been opened in 1815 and in 1828 by Dupuytren; in 1832 by Ahrt, and in 1843 by Willard Parker, of New York. Grisolle, in 1839, advised against the usual custom of blindly plunging the bistoury into the abscess in these cases, and urged the importance of cautiously dissecting down through the overlying tissues, because a coil of intestine might intervene. He never, moreover, would open such an abscess until fluctuation was present, nor until it had become adherent to the abdominal walls.

But in 1848 occurred the greatest surgical advance of the century, when Hancock performed the first deliberate laparotomy for peri-appendicular suppuration, and proposed such treatment for all cases with abscess before pointing or fluctuation had occurred, or even before adhesions to the anterior abdominal wall had formed.

This was looked upon by many as a procedure foolhardy in the extreme, in spite of the excellent recovery made by his patient. The details of the case are as follows: A woman of thirty years, who had been subject for some years to pains in the right iliac region, had a recurrence of this pain the day after parturition. She was at first treated with sedatives; then an enema; then leeches, with warm fomentations, to the abdomen; and was likewise given opium, calomel, and salines. On the fifth day first could any mass be felt. When Mr. Hancock first saw her, on the eighth day of this attack, the right iliac region was so sore from blistering that the physical examination was unsatisfactory; but he made a diagnosis of trouble around the cæcum or the appendix. Two days later examination was possible, and showed the patient sinking, with symptoms of general peritonitis, and a deep seated mass internal to the right anterior superior iliac spine. There was no evidence of fluctuation. Mr. Hancock thought nevertheless it was probable that pus was present, and advised cutting down on this mass, to evacuate any matter that might exist. Under chloroform anæsthesia, he therefore made an incision four inches in length, from the iliac spine inward, close to Poupart's ligament; and on opening the abdominal cavity evacuated a quantity of excessively offensive, turbid serum, with fibrinous flocculi, mixed with air globules and patches of false membrane. The patient was now turned on her side, to allow a free escape of the matter; a poultice was applied, and an opiate directed to be administered. After a tedious illness of two weeks, two fæcal concretions were removed from the sloughing sinus. These were faceted, and evidently had been impacted in the appendix and had escaped from it by ulceration. "From this date she got well," adds Mr. Hancock.

Not until 1856 was Hancock's advice repeated. In this year Lewis reiterated the importance of opening abscesses in this situation early, without waiting for fluctuation to appear, since by that time many patients would be dead. He analyzed forty cases of abscesses in the right iliac region. But Willard Parker, in 1866, was the first to put into practice again this method of treatment. He advocated operation between the fifth and the twelfth day, after adhesions had formed, but before the accumulating pus had ruptured them.

Most of these operations were done by Hancock's original incision; and some less daring operators incised down only to the transversalis fascia, and then either allowed the abscess to break through of itself, which it usually did in the course of a few hours; or else they punctured the abscess with trocar and cannula, and subsequently dilated the sinus thus formed. (See Weber, Whittall, Kolb.)

The introduction of the drainage tube by Chassaignac, in 1859, materially aided the cure of these cases. In 1860* Münchmeyer first made a counterincision in the loin to facilitate drainage.

In 1865 Buck opened a perityphlitic abscess pointing in the right groin, below Poupart's ligament; and from this opening in the thigh, a pin subsequently was discharged, evidently being the cause of the disease.

By the year 1883 the number of operators had become so great that Noyes was enabled to find records of no less than one hundred cases where the abscess had been opened by puncture or incision. A curious operation was performed in this year by Symonds: by a curved incision of four inches in length, close to the iliac bone and Poupart's ligament, working across adhesions, he removed a calculus from a chronically affected appendix and then sutured his incision into the vermiform process. A large tube was placed down to the wound in the appendix, this organ evidently being adherent to the parietal peritoneum, so that the general cavity was not opened. The patient recovered and had no return of his symptoms. This method of procedure was planned by Dr. Mahomed, and, as will be remembered, carried out a suggestion made by Blackadder as early as 1824.

In 1884 Krönlein first removed the appendix for acute disease. He employed an incision through the linea alba. His patient did not recover.

Homans in 1886 operated on a case of appendicular abscess, which he opened across the general peritoneal cavity, protecting this from the contact of the pus as well as he was able. He is said by Edebohls to have employed gauze packs for this purpose, but the original article makes no mention of them. The patient recovered.

On April 21, 1887, Weir made a diagnosis of appendicitis, and, after opening the normal peritoneal cavity, evacuated an appendic-

ular abscess and removed the appendix; but his patient did not recover. A few days later (April 25) Thos. G. Morton operated on a patient with peritonitis, and through an incision ten inches long removed part of a perforated appendix, the patient recovering. In the original report of this case it is not stated that the correct diagnosis had been made before operation, though this claim was later advanced.

In 1887 Sands successfully closed a perforation of the appendix by suture, while in 1888 Treves did laparotomy for "relapsing typhlitis," and found the omentum adherent to the appendix, which was thus kinked. Treves therefore cut the adhesion, sutured a tear in the peritoneum thus made, bared the convex surface of the appendix of its peritoneal coat, thinking it would thus contract new adhesions with the parietal peritoneum on its outer side, and so be held straight, and closed the abdominal wound leaving the appendix in its new position. Recovery ensued. Being encouraged by his experiences, he next removed the appendix for recurrent attacks, during an interval of quiescence, closing the stump of the appendix with two sutures, and then stitching a flap of cæcal peritoneum over the stump, considering this a much safer method than merely to ligate the appendix before amputating it, as had been done by his predecessors. This was the first operation in an "interval."

In 1889 Tait split open and drained an inflamed appendix, without removing it. His patient recovered. In the same year Schüller first successfully closed an abdomen without drainage after an operation for appendicitis in which the peritoneal cavity was found to contain turbid serum. Each operation is an instance of a custom which has in later years been thought more honored in the breach than the observance.

Among other surgeons who operated in cases of this kind before 1890 were:

Adams, Bacon, Bailey, Barlow and Godlee, Barret, Beach, Boardman, Bontecou, Briddon, Bryant, Buck, Bull, Burge, Byrd, Cage, Chamberlain, Chaput, Clarke, Clay, Cutler, Deaver, Edebohls, Ely, Freeman, French, Fries, Gibney, Gouley, Grant, Hall, Heath, Hicks, Hoffman, Holden, Howe, Jarvis, Kelsey, Köhler, Kolb, Krockowizer, Leale, Lewis, Maclaren, Mason, McBurney, Merriam, Mikulicz, Miner, Moore, Mynter, North, Noyes, Par-

tridge, Pierson, Pinckney, Polaillon, Poncet, Pooley, Potter, Post, Raub, Regnier, Stemen, Stiegle, Stimson, Van Buren, Vander Veer, Voss, Walker, Ward, Weber, Weinlechner, Wey, Whittall, White, and Woodard.

When an abscess was not pointing the usual incision was through the right semilunar line, but in the last decade of the century this custom was rapidly abandoned for either the incision through the right rectus muscle, or for some form of "muscle-splitting" incision, which was at first considered suitable only for chronic cases, or for "interval" operations.

The simple straight incision through the right rectus muscle is said by Sprengel to have been used first in 1884 by Gagen-Thorn, later by Ziegenspeck, Ramsey and others. Later it was known by Lennander's name, and in this country by those of Edebohls and Deaver. This incision was modified by Battle in 1895, by Jalaguier and by Kammerer in 1897, and by Lennander in 1898, each of whom, apparently independently, proposed to draw the muscle toward the median line, after opening its sheath by a longitudinal incision, without separating or dividing its fibres. The original "grid-iron" or "muscle-splitting" incision was proposed by McBurney in 1893; and has since been further modified to gain more room in case of emergencies. One modification was that proposed by Harrington in 1899 and by Wier in 1900: this consists in dividing the rectal sheath in the same transverse line as the deeper portion of the original incision, and drawing the rectus muscle toward the median line. Elliot in 1896 described an incision somewhat similar to that of McBurney, except that the superficial as well as the deeper tissues were divided in a transverse direction; he proposed to enlarge this by cutting up and down in the semilunar line, or by extending the cut into the rectus muscle. Chaput in 1905 described a similar incision. The transverse incision of G. G. Davis (1906) opens the sheath of the rectus muscle anteriorly and posteriorly, and divides the oblique muscles in the same line.

The stump of the appendix in the earlier operations was merely ligated. Treves, as above mentioned, was the first to suture the stump. Dawbarn introduced in 1894 the method of inverting the stump without ligating it, by a purse-string suture, which may be applied even before the appendix is removed, and tightened afterward.

There are three therapeutic measures, introduced to the notice of the profession within recent years which merit short notice in this historical review, though they are discussed elsewhere in the volume. In chronological order these are (1) the Fowler position; (2) the Murphy method of operation and aftercare; and (3) the Ochsner treatment.

The late Dr. George R. Fowler observed for some time previous to the publication of his observations in 1900 that those patients under the care of his assistant Dr. R. S. Fowler did better, who, for the purpose of diminishing post-anæsthetic vomiting, were treated by having the head of the bed elevated from twelve to fifteen inches above the floor, and he therefore adopted this position as a postural treatment in cases of spreading, diffuse, or general peritonitis, as a matter of routine; hoping by the force of gravity to confine the infectious material to the lower portions of the abdomen, whence absorption is much less rapid than in the diaphragmatic region. It is to be noted that these patients were not placed in the sitting position. The true "Fowler position" is the head high position secured by elevating the head of the patient's bed from ten to twenty inches from the ground, and thus changing the plane of the bed to an angle of perhaps fifteen to twenty degrees with the horizon. Soon after this time the sitting posture was introduced, largely through the influence of Mayo and of Robson and Moynihan, with the idea that it mechanically favored drainage of the stomach after gastro-enterostomy. Though this theory has since been abandoned, the benefit derived from sitting these patients up in bed is incontestable, and this position is now very generally adopted in cases of peritonitis in preference to Fowler's position.

Murphy, in August 1904, gave his conclusions based on his experience with two thousand cases of appendicitis. The special feature, with which his name is associated, was the treatment advocated for cases of spreading, diffuse, or general peritonitis. Emphasis was laid on (1) speedy operation, with limited intra-abdominal manipulations; (2) the sitting posture, the body being raised to an angle of thirty-five to forty-five degrees; and (3) the administration of large quantities of saline solution (four to twelve quarts in twenty-four hours) by the rectum.

Ochsner, in a paper based on an experience in one thousand

cases of appendicitis, read October 14, 1904, before the Tri-State Medical Society, offered the following as among his suggestions for treatment of appendicitis, with a view of reducing the mortality: Operation in all interval cases; immediate operation in all acute cases "provided they come under treatment while the infectious material is still confined to the appendix;" the absolute prohibition of all food and cathartics by mouth, and of large enemata; gastric lavage for nausea, vomiting, or gaseous distention; and finally that in cases coming under observation after the infection had extended beyond the tissues of the appendix, especially in the presence of beginning diffuse peritonitis, the "starvation treatment" as it has been called, and as above outlined, should always be employed "until the patient's condition makes operative interference safe." Moreover, he urged that "in case no operation is performed, neither nourishment nor cathartics should be given by mouth until the patient has been free from pain and otherwise normal for at least four days."

The two most important articles that have yet appeared dealing with the history and literature of appendicitis are those of Clado and Edebohls, both of which have been freely drawn upon in the preparation of this sketch.

If, then, we review the miscellaneous facts hitherto set forth in rather unpalatable form, we find that the existence of the vermiform appendix was unknown until the sixteenth century; and that from the mere mention of it in anatomical works of that period, a gradually increasing familiarity with its structure is evident, until the beginning of the nineteenth century, when an anatomical knowledge, which may be called modern, had been gained. We find, however, that the symptoms of a disease, which we now know as appendicitis, were described with an amount of accuracy sufficient for recognition at the present day, even by authors of classic times; but that no one except perhaps Méliér, in 1827, considered disease of the vermiform process as the chief, if not the sole, cause of these symptoms, until Matterstock in Germany, and Fitz in America proved, over a generation ago—the former, that practically all right iliac phlegmons were associated with a perforated appendix—

and the latter, that in cases of so-called typhlitis, and in cases of appendicitis, the symptoms were identical.

That a knowledge of the pathology of the vermiform appendix slumbered, nay, even hibernated, from the time of Mélier, until the day of Fitz, is one of the most remarkable things in the whole history of medicine; and that it was at last awakened is due in no small measure to those courageous surgeons, like Hancock and Willard Parker, who determined to evacuate perityphlitic abscesses externally before these abscesses could kill the patient by intra-peritoneal rupture; and to all those operators, notably to McBurney, Fowler, Price, Morris, Richardson, and Murphy, who, inspired by their example, determined to remove the offending organ before the inflammatory process had advanced beyond its earliest stages, at a time when the general peritoneal cavity was yet healthy, and when ablation of the diseased organ meant cure without hope of relapse.

ANATOMY.

The vermiform appendix of man is, from an anatomical standpoint, the partly developed lower end of the cæcum, which does not undergo the same degree of growth and distention as does the rest of the cæcum. In the embryological development of the human intestinal tract there is at first no cæcum present, the original tract consisting of a straight tube, which, for purposes of description, has been divided into the fore-gut, the mid-gut and the hind-gut, and is attached to the umbilicus by the vitelline duct, sometimes persisting in the adult as Meckel's diverticulum. This attachment of the gut to the anterior abdominal wall pulls the formerly straight tube into a U-shaped projection, consisting of an upper and lower limb. At the end of the sixth week of intra-uterine life the cæcum is well-marked, budding from the lower limb of the primitive intestinal loop, and marking the division between the small and the large intestine. The lower limb of the loop then ascends across the upper, past the umbilicus, to the left hypochondrium, thence across to the right hypochondrium, and finally about the end of the sixth month reaches the right iliac region, though even at birth and in early childhood the cæcum is placed higher than in adults. The cæcum may be arrested at any part of its journey, and when at operation it is not found in the right iliac region it may be looked for in either hypochondriac region, or near the umbilicus. A number of instances are recorded of its position in these abnormal situations, the ascending colon or this and the transverse as well being absent. Byron Robinson in an analysis of autopsies of 300 male and 118 female bodies, found partial non-descent of the cæcum in 7 per cent. of the former and 3 per cent. of the latter. Lennander mentioned the case of a boy, aged sixteen years, in whom the cæcum and appendix were found in the left hypochondriac region, lying against the spleen. In this case the appendix measured nine inches in length.

Some cases are recorded where the appendix is said to have been absent. Byron Robinson figures the condition found by him

at autopsy in a woman of fifty years, where both cæcum and appendix were congenitally absent, the ileum opening into the ascending colon without perceptible angulation. I have never found the appendix absent on the operating table.¹

Further studies in comparative anatomy support the physiologist's claim that the appendix should be considered as a lymph gland—as the abdominal tonsil. Berry examined the cæcal apex or, when present, the vermiform appendix in the following classes of life: Pisces, Amphibia, Aves, and Mammalia, including Marsupialia, Edentata, Ungulata, Rodentia, Carnivora, Insectivora and Anthropeoidea. Examination of the skate and the frog was negative; but, with the exception of a few others, all were found to present as their one common characteristic a large amount of lymphoid tissue. In the cat, pigeon and other animals with short cæca, the lymphoid tissue tends to be aggregated in distinct masses; when the cæcum is long, as in the domestic fowl, the pig and the sheep, the lymphoid tissue is diffused throughout the cæcum. In all instances the lymphoid tissue tends to be better marked at the cæcal apex, and to be comparatively wanting in other regions of the intestinal tract. His conclusions are:

1. Lymphoid tissue is the characteristic feature of the cæcal apex. The vermiform appendix of man is, therefore, represented in the vertebrate kingdom by a mass of lymphoid tissue, situated most frequently near the cæcal apex.

2. As the vertebral scale is ascended this lymphoid tissue tends to be collected together into a specially differentiated portion of the intestinal canal—the vermiform appendix.

3. The vermiform appendix of man is not therefore a vestigial structure. On the contrary, it is a specialized part of the alimentary canal.

Types of Cæcum.—In the adult the cæcum develops as one of four types, and in each class the appendix holds a different position. (Fig. 3.)

1. In the foetal type the appendix is the narrow inferior end of the conoid cæcum, the apex of the cone being directly continued into the appendix.

¹ Other instances where the appendix was absent have been recorded by Fawcett (two cases), Ferguson, Schridde, Swan (two cases), Dillard and Dorrance.

2. The second type consists of a cæcum with two equally large sacculi at its inferior termination. The appendix arises from the lower end of the cæcum, between the sacculi, which are separated by the anterior longitudinal band.

3. In the third type the external sacculus is large, while the internal one is small, thus bringing the base of the appendix near the ileo-cæcal valve. In addition, the anterior wall of the cæcum grows more rapidly than the posterior, so that the root of the appendix is posterior.

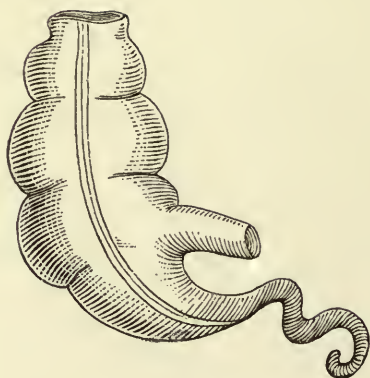
4. In the fourth and last type the internal sacculus has disappeared entirely, and the base of the appendix is attached to the cæcum posterior to the receding angle between the ileum and cæcum.

The first type of the cæcum is very rare; the second is not commonly seen; and the cæcum is usually of the third type, or partakes of the character of the third and fourth types. Woolsey says that type one is found in only 2 per cent. of cases; type two in 3 per cent.; type three in 90 per cent., and type four in 4 or 5 per cent. According to Bryant's statistics, in more than one-half of all cases the appendix arises from the posterior surface of the cæcum about one inch below and to the right side of the ileo-cæcal valve; and in nearly all cases the root of the appendix is upon the postero-internal portion of the cæcum, from three-fourths of an inch to one and a half inches from the ileo-cæcal valve. Innumerable observations in the dissecting room and at the operating table, moreover, have proved to the author that the cæcal attachment of the appendix is almost always upon the postero-internal portion of the cæcum. There are, however, rare instances in which the appendix arises from the anterior surface of the cæcum.

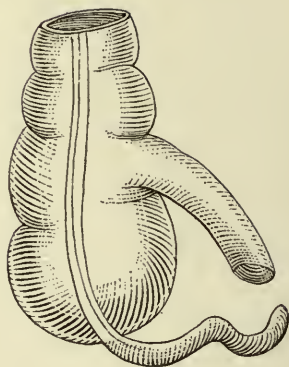
In cases of non-descent of the cæcum the appendix holds a correspondingly abnormal position, and under such circumstances it may lie even to the left of the median line.

Length and Diameter of the Appendix.—Although the average length of the appendix is from 8 cm. to 9 cm., its length may vary from 1 cm. to 23 cm. When the appendix is long, the cæcum is, as a rule, somewhat shortened. The diameter of the appendix is that of a goose-quill, or about that of a large earthworm (Holden)—from 3 mm. to 5 mm.

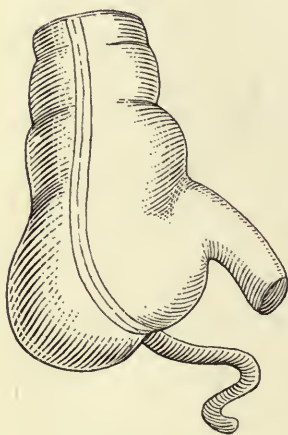
Peritoneal Coat of the Cæcum and Appendix.—The cæcum



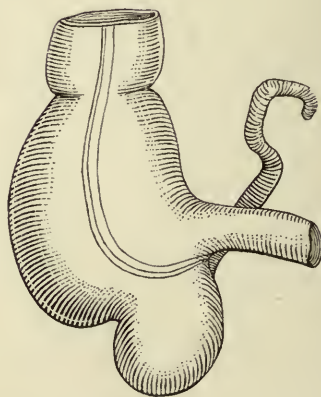
I



II



III



IV

FIG. 3.—THE FOUR PRIMARY TYPES OF CÆCUM.

is usually almost completely covered by peritoneum. Its anterior surface is entirely invested by a serous covering; a small area on the posterior surface, however, is frequently left uncovered by the divergence of the two layers of the proximal portion of the meso-appendix. In rare instances, moreover, the cæcum has been found to be almost entirely retro-peritoneal, the whole ascending meso-colon, indeed, being practically non-existent. In such cases the cæcum and appendix occupy a fairly fixed position; whereas, when the meso-colon and meso-cæcum are long, the cæcum, being free to move, may, with the appendix, be carried by the ileum even into the sac of a left-sided inguinal hernia.

The peritoneum nearly invariably invests the distal portion of the appendix completely, but throughout the proximal half or two-thirds there is usually a meso-appendix; and close to the base of the appendix there is frequently on the posterior or inner surface a small triangular space uncovered by peritoneum. Sometimes the meso-appendix is absent, and the appendix hangs free in the peritoneal cavity; or, on the other hand, the appendix may be entirely subserous, lying beneath the peritoneum in almost any position. It usually, in such cases, runs up behind the cæcum, either to its outer or inner side, being situated between the layers of the meso-cæcum or of the ascending meso-colon; but has also been found running up the anterior surface of the cæcum, between its muscular and serous coats. Pointing downward it may be beneath the iliac or pelvic peritoneum, lying against the corresponding fascia; in such cases a pelvic abscess may occur, which will be extra-peritoneal, or the pus may burrow along the external iliac vessels, and the abscess point in the thigh, beneath Poupart's ligament.

The **meso-appendix** is a double layer of peritoneum, similar to, but on a smaller scale than the mesentery, from the under or left layer of which it is derived. It is either triangular or quadrangular in outline; when the former, its free edge may be considered to form the base of the triangle, while its apex is at the root of the appendix, and the two sides are formed, one by the appendicular attachment, and the other by its origin from the mesentery. The base, or free edge of the meso-appendix nearly always forms an acute angle with the attachment of the mesenterium to the appendix; and in some cases is continued even to the tip of the appendix as an exceedingly

narrow fringe, almost invisible to the naked eye. When quadrangular in outline, the fourth side, at the cæcum, is usually the shortest of all. The meso-appendix usually appears to be too short for the appendix, thus twisting, curving or coiling it as the mesentery does the small intestine throughout its length. The form of the proximal portion of the meso-appendix varies slightly according to the type of cæcum: where this is of the first or second type, the proximal part of the meso-appendix is continued as the meso-cæcum, the left layer of which is continuous above with the under layer of the mesentery of the ileum, and below with the left layer of the meso-appendix; the right layer being continuous below with the corresponding layer of the meso-appendix, and above forming the right layer of the ascending meso-colon. The upper portion of the posterior surface of the cæcum is usually left bare of peritoneum by the divergence of the two layers of the meso-cæcum; where this is not the case, abnormal mobility of the caput coli and appendix ensues, as was described above. In the third type, or in types which are intermediary between the third and the fourth, the meso-cæcum appears at first sight to be absent; search, however, reveals it, though shortened, still formed by the diverging layers of the proximal portion of the meso-appendix. The more nearly the cæcum approaches the fourth type, the less distinct becomes the meso-cæcum, since in this type the meso-appendix arises entirely from the under layer of the mesentery, and the proximal part of its right layer is continuous with the serous coat of the cæcum, and with the peritoneal lining of the iliac fossa, the junction of the last named two portions of peritoneum forming the outer layer of the meso-cæcum, while its inner layer is so short as to be practically non-existent. As the form of cæcum approaches the first type, the freedom of motion of the appendix increases, so that at operations for their excision, appendices of this type are more easily brought through the abdominal wound than are those of other types, since a longer meso-cæcum is present. Perforation occurring, as it occasionally may, at the small triangular area near the base of the appendix, above described as uncovered by peritoneum, or in the line of attachment of the meso-appendix, would open into the interval between the two layers of the meso-appendix. As a consequence of such perforation, pus may pass into the mesentery and thence to

the subperitoneal areolar tissue of the iliac fossa; or, at the proximal portion of the meso-appendix, the pus may enter the post-cæcal areolar tissue, and thence gravitate to the iliac fossa; or, rarely, it may burrow upward behind the colon and simulate perinephric abscess.

Between the layers of the meso-appendix are found the arteries, veins, nerves, and lymphatics for the appendix, together with areolar tissue and some fat. In some instances the iliac vessels pass through the meso-appendix, thus accounting for one manner in which collections of pus in the right iliac fossa may find their way beneath Poupart's ligament into the thigh. In the female the meso-appendix sometimes has running to the ovary a prolongation, which is called by Clado the appendiculo-ovarian ligament. It conveys an additional blood supply to the appendix, and will be described in more detail later in connection with that subject. I have myself never met with this structure, and its presence is denied by some excellent authorities.

The meso-appendix acts also as an appendicular ligament, the mobility of the appendix depending, when adhesions are absent, largely upon the width and the length of attachment of the meso-appendix. In the rare cases where the mesenterium is entirely absent, the appendix is freely movable in the abdominal cavity.

At times in the meso-appendix may be found an opening, in which a coil of small intestine has been known to have become strangulated.

Position of the Appendix.—In the majority of cases the appendix holds one of eight positions. Dr. Bristow suggests a very simple method of classifying these positions and directions. This consists in locating in the right iliac fossa a central point which represents the most frequent position of the attachment of the appendix to the cæcum; from this central point are drawn lines which radiate in eight different directions. To indicate the course of the different lines, Fowler has modified this method by substituting the initial letters of the points of the compass for the numbers used by Bristow. The central point is located by drawing a line from the anterior superior spine of the ilium to the umbilicus; a point on this line, from two to two and a half inches from the anterior superior spine, marks the position of the root of the appendix and is the central point from which the lines are drawn.

Although the appendix may occupy any of the eight positions of the points of the compass, it is most commonly found in one of

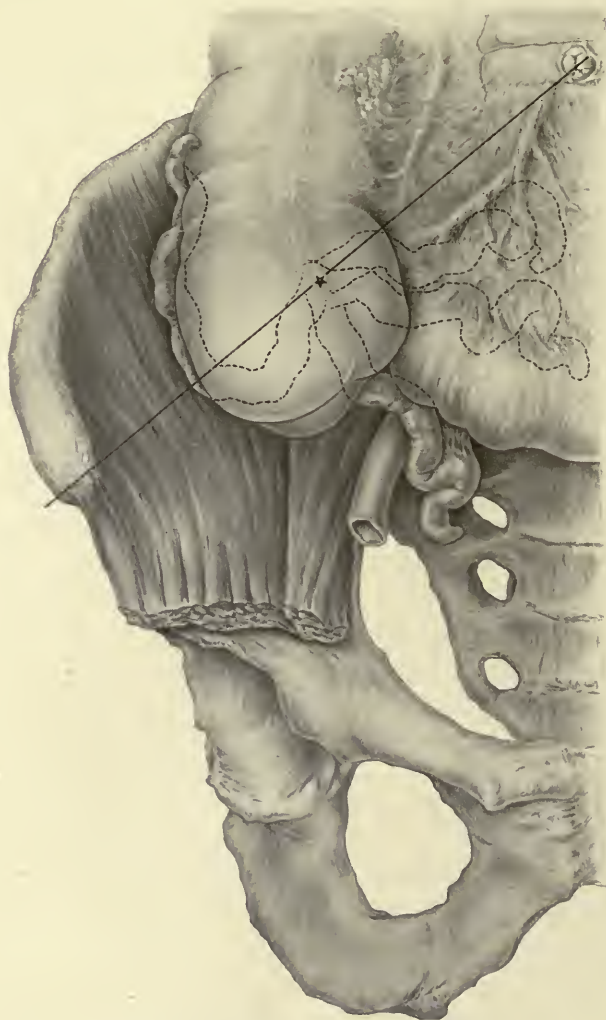


FIG. 4.—POSITIONS OF THE APPENDIX.

1. Under the mesentery. 2. In the pelvis. 3. On outer side of cæcum

the following: (1) It may lie under the inferior layer of the mesentery, being directed toward the spleen—in the N. E. position; (2) it may lie on the ilio-pectineal line or may project into the pelvis,

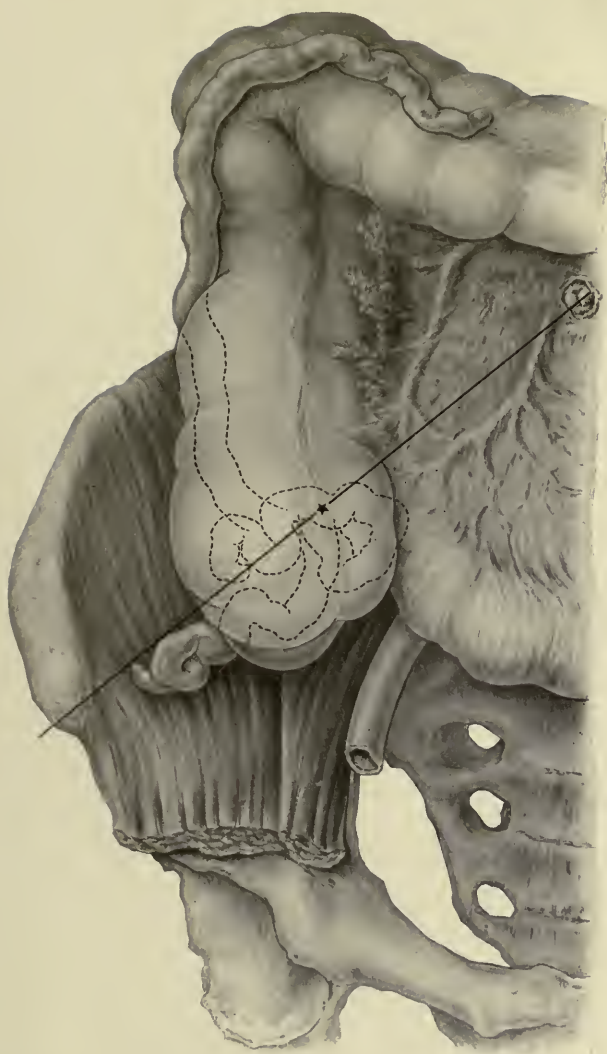


FIG. 5.—POSITIONS OF THE APPENDIX.

1. Coiled up behind cæcum. 2. Lying down and out on iliacus muscle. 3. Abnormally long appendix extending beyond hepatic flexure of colon.

its course being S. or S. E.; (3) if there be a long meso-appendix, it may lie to the right of the cæcum and the ascending colon, running upward, in a northerly direction parallel with the colon and over the kidney toward the right lobe of the liver; (4) it may lie in front of the colon and cæcum, its course generally being N. or N. E.; (5) it may lie behind the cæcum, holding generally a northerly direction; (6) if the appendix has a long and wide mesentery, it may be directed toward any of the other points of the compass, freedom of motion generally being required in order that it assume any of these positions; (7) when the meso-appendix is short, the appendix may be coiled upon itself.

Abnormally, the appendix may hold a position in either of the ileo-cæcal fossæ; it may lie behind the peritoneum and behind the cæcum and may be in contact with the posterior muscular wall of the latter (see Fig. 7), being covered in this position by the peritoneal coat of the cæcum; it may be adherent to the peritoneum along the right border of the cæcum and ascending colon or at any point in the neighborhood of the cæcum; or it may lie in the inguinal canal.

It seems more simple and practical, however, to classify the positions of the appendix as follows: (1) Upward or upward and outward, lying in front of, behind, or upon the outer or inner side of the cæcum; (2) under the mesentery and directed upward and inward, inward, or downward and inward over the brim of the pelvis; (3) coiled upon itself and lying under the cæcum; (4) downward, lying free in the abdominal cavity under the cæcum; (5) outward, lying in front of or behind the cæcum.

When the appendix is directed upward or upward and outward, and lies behind or upon the outer side of the cæcum or colon, an abscess resulting from disease of this organ frequently produces its local manifestations in the loin and simulates abscess of hepatic or renal origin. When the inflamed organ is directed downward and inward or downward into the true pelvis, the bladder or the ovaries are irritated. The following are from statistics collected by Bryant in the dissecting room from 144 subjects: The appendix held one of the upward positions in relation with the cæcum in 11 cases, or less than 8 per cent.; it was under the mesentery and directed upward and inward, inward, and downward and inward in 92 cases, or about 64 per cent.; it was coiled upon itself under the cæcum in 1

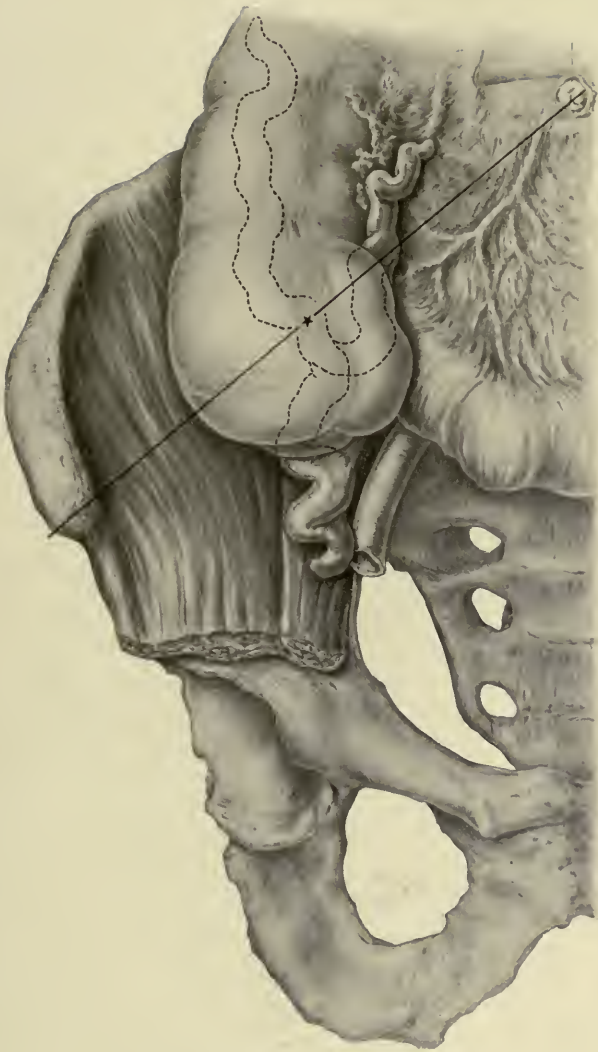


FIG. 6.—POSITIONS OF THE APPENDIX.

1. Lying on top of mesentery to inner side of cæcum. 2. Lying on outer side of ascending meso-colon, behind cæcum. 3. Pointing directly downward, below cæcum; the tip of appendix in contact with external iliac artery.

case, or less than 1 per cent.; it was directed downward or downward and outward or lying under the cæcum in 38 cases, or less than 27 per cent.; it was directed outward in 2 cases, or less than 1.5 per cent.



FIG. 7.—AN UNUSUAL POSITION OF THE APPENDIX.

Adherent to the posterior surface and covered by the serous coat of the cæcum.

The position of the appendix at autopsies has also been investigated by Monks and Blake, 572 cases; by Boody, 509 cases; and by Byron Robinson, 418 cases. Unfortunately these observers have not classified their experiences in the same way, so that it is

difficult to make a synopsis of their observations. Robinson has classified the various positions in which he found the appendix, as regards its relation to the psoas muscle; while the other authors divide their cases into groups where the appendix was bound down, down and in, in, up and in, etc. In Robinson's series the results may be presented as follows:

MALES—300 CASES.

37 per cent.	hung in the pelvis.	48 per cent.
46 per cent.	on the psoas muscle.	20 per cent.
23 per cent.	to the left of psoas muscle.	20 per cent.
20 per cent.	retro-cæcal	35 per cent.
18 per cent.	to right of psoas muscle.	28 per cent.

FEMALES—118 CASES.

Irrespective of sex, he found that 80 per cent. of the appendices were to the right of the psoas, and 20 per cent. to its left.

The results of the two other series of observations may be combined in the following table:

Author.	Number of cases.	Down. and in.	Down	In.	Up.	Up and in.	Up and out.	Out.	Down and out.	In pelvis.	Behind cæcum.
Monks and Blake	572	179	79	62	52	39	29	9	5	14	104
Boody	509	64	42	6	43	270	84
Total	1081	243	121	68	95	309	29	9	5	14	188
Per cent.		22.6	11.2	6.3	8.7	28.5	2.6	0.8	0.5	1.3	17.5

Thus it is seen that the most usual postmortem positions are up and in, and down and in, the combined percentages of these two positions from the above table being over 51 per cent.; Bryant's figures, quoted above, being about 64 per cent. for these positions. In my own operative experience, the position of the appendix in the great majority of cases has been down and out, lying in the sulcus on the outer side of the psoas muscle; but my observations in the

dissecting room confirm the above statistics, that is, that positions of the appendix under the mesentery are most common.

Histology of the Appendix.—Physiologically the appendix has of late years been regarded more and more as a lymphoid structure, some even claiming for it the rôle of a gland, under the name of the abdominal tonsil. Microscopically the resemblance is fairly close, the predominance of lymphoid structures in both organs being obvious.

The coats of the appendix are a mucous, a submucous, a muscular and a serous. Its structure is very similar to that of the cæcum and the lower ileum.

The *mucous membrane lining the appendix* is composed of a single layer of columnar epithelial cells, placed upon a basement membrane; of tubular glands reaching down to a delicate muscularis mucosæ, which is often absent; and of lymphoid follicles. The tubular glands and the lymphoid follicles are embedded in a delicate retiform connective tissue. The former are about 0.5 mm. in length, and are said by Lockwood, who is the best recent writer upon the subject, to be bifid and sometimes trifid at their extremities, thus giving them the appearance of racemose glands. They do not extend beneath the muscularis mucosæ, as above mentioned, whereas the lymph follicles, some of them, pierce it and enter the submucosa, which is separated, often imperfectly, from the mucosa by the muscularis. The lymphoid tissue in which the tubular and lymph glands are embedded becomes in inflammatory conditions obscured by the round-celled infiltration, which may completely obliterate the retiform structure. Thus the extent to which this delicate connective tissue is hidden by the inroad of the inflammatory cells is a rough index of the intensity of the inflammation.

At the cæcal orifice of the appendix there is sometimes a prominence of the mucous membrane, caused by increase of the lymphoid tissue, forming a small valve, well described by Gerlach. Under certain circumstances this may favor occlusion of the orifice. In a certain proportion of cases, moreover, the appendix enters the cæcum obliquely, as the ureter does the bladder, and thus forms a sort of valve.

The lymphoid follicles are distinctly visible to the naked eye, being about 1 mm. in diameter. In shape they are circular or oval,

and are almost entirely within the ring formed by the muscularis mucosæ, only a few being without in the submucous tissues. Lockwood estimates their entire number in the average appendix at from 150 to 200 follicles. In the centre of the follicle, which stains less deeply, the lymph channels are more capacious; while the cortical area stains well, and is quite opaque. The base of the follicle reaches the submucosa, but between them is found a space described as the follicular or basilar lymph sinus, which communicates freely with the lymphatics of the submucosa.

The *submucosa*, beneath the muscularis mucosæ, is formed of fibro-elastic areolar tissue. Where, as is usually the case, the muscularis is absent or at least only imperfectly developed, the separation of the submucosa from the mucosa is very indefinite. The submucosa contains numerous small arteries and veins, which supply the mucous membrane; also lymphatic vessels, a few lymph follicles, and a small quantity of fat. The thickness of this layer is extremely variable.

The *muscular coat* consists of two layers. The inner is a fairly thick layer of circular fibres which at times constitute fully one-third of the entire thickness of the appendicular wall. This layer contains scarcely any connective-tissue cells, and very few blood-vessels; hence it stains deeply. The outer layer is composed of longitudinal fibres, not so thick as the inner layer, and in places nearly absent, being often collected into longitudinal bands, somewhat resembling the analogous arrangement in the cæcum. Between these longitudinal bands are found blood-vessels and lymphatics. At certain places gaps may be seen in the muscular coat, allowing the submucous and subperitoneal tissues to come directly into contact with each other, and serving for the transmission of blood and lymph vessels from the meso-appendix to the submucous and mucous coats. Lockwood has called special attention to this *hiatus muscularis*, as he terms it, as the chief avenue of infection from the deranged epithelial lining of the appendix to the subperitoneal tissues and the peritoneum. These gaps, of course, occur only along the mesenteric attachment, and near the cæcal end may frequently be observed with the naked eye.

The *peritoneal coat of the appendix*, like similar membrane found elsewhere, is formed by a fibrous and a serous, or endothelial layer.

The former is next the muscular coat, its delicate connective tissue penetrating among the longitudinal bands of the outer layer, and carrying in its meshes minute blood-vessels, nerves and lymphatics. The endothelial covering consists of a single layer of irregularly polyhedral cells whose serrated margins are accurately apposed. The existence of actual stomata or preformed openings at intervals between these cells is now denied by Muscatello and others. Lymphatics, however, course immediately beneath the endothelium which offers but little obstacle to the escape of infection into the general peritoneal cavity once it has reached the subperitoneal lymph channels.

The **vascular supply of the right iliac fossa** is derived from two loops formed by anastomosis of branches of the superior mesenteric artery. One loop is formed by the anastomosis of a descending branch of the colica dextra with an ascending branch of the ileo-colic artery, and the other loop by the junction of descending branches of the ileo-colic with terminal branches of the superior mesenteric artery. From the loop first described arise the ileo-cæcal arteries, known from their relation to the ileum as anterior and posterior. The anterior is the smaller, and, while supplying the anterior surfaces of the cæcum and lower ileum, rarely reaches as far as the appendix. It occasionally, however, sends minute twigs to the base of this organ. The posterior ileo-cæcal artery, on the other hand, is the chief source of the blood supply of the appendix. It passes down behind the ileum, close to the cæcum, sends branches to the back of the lower ascending colon, to the cæcum, to the end of the ileum, and to the appendix. The cæcal branch, mentioned above, coming from the posterior ileo-cæcal artery, runs across the lower inner part of the cæcum, near the origin of the appendix, and gives off one or more branches to the base of the appendix. During foetal life, before the appendix has developed a mesentery, this is the only blood supply, and hence in adult life the most constant; and where no mesentery to the appendix exists is even in adults the sole source of blood supply. But in the majority of individuals the main blood supply of the appendix is derived from the posterior ileo-cæcal through its appendicular branches, which run between the layers of the meso-appendix. These branches are usually three in number, the largest running in the free

edge of the mesenteriolum, and the two shorter branches supplying the body and base of the appendix. It is a well-known fact that perforation is prone to occur at the point where the meso-appendix ceases, and that gangrene is especially liable to attack the free tip of the appendix, where it has no mesentery. These facts are sufficiently explained by a knowledge of the blood supply as above described.

In the female in about one case in ten (Clado) there is an appendiculo-ovarian ligament, prolonged outward from the infundibulo-pelvic ligament to the meso-appendix. Durand identifies it with the superior fold of the mesovarium, or "plica vascularis" of Lockwood. This fold of peritoneum carries a small artery from the ovarian to anastomose with the mesenteriolar appendicular arteries, thus in some females giving a third source of blood supply to the appendix; as well as by the lymphatics it carries allowing ready transit of infection from the adnexa to the appendix, and *vice versa*. As already remarked, I have not myself met with this structure, either at operations or in the dissecting room; and its existence has been denied by excellent authorities. (See an article by Coe, in the N. Y. Med. Journ., 1904, ii, 254.)

The *veins of the appendix* are the most dependent of the branches of the portal, the sigmoid and hæmorrhoidal veins being excepted. This fact, together with the thinness of their walls and their disproportionately large lumens, explains their proneness to engorgement. These veins arise in the submucous and the subperitoneal tissues. The former pass out with the arteries and lymphatics through the muscular gaps into the meso-appendix, thence to a posterior cæcal vein, from this into the ileo-colic, and so into the portal system. The subperitoneal veins pursue mostly the same course, but a few empty directly into the cæcal veins.

The **lymphatics of the appendix**, arising as has been described in the basilar lymph sinuses in the mucous layer, pass out through the hiatus musculares into the meso-appendix, where some of them pass through the appendicular lymph gland, which is not always to be found. They then pass into a chain of lymph glands lying in the ileo-colic angle, along the inner border of the ascending colon. Some no doubt pass into the mesenteric lymph glands, but the former is probably the more frequent route. These ileo-colic glands have

been found enlarged in malignant disease of the cæcum, and have been excised with the neighboring intestine. Moreover, some lymphatics from the appendix empty into the glands along the external iliac vessels, and others again are said to pass by way of Clado's ligament to the broad ligament, the pelvic connective tissue, and the internal iliac glands.

The **nerves of the appendix** are derived from the superior mesenteric plexus of the sympathetic nerve, the branches of the plexus which accompany the ileo-colic artery sending filaments to the appendix. One set of branches supplies the peritoneal and muscular coats, while another set pierces the muscular coats at the gaps, and supplies the blood-vessels of the mucosa. The small intestine receives numerous twigs from this same plexus of the sympathetic, so that pain from the appendix may be referred over a wide area.

In addition to the knowledge of the intrinsic nerves of the appendix it is of much importance to consider the various nerves of the abdominal wall through which referred pain is felt. This referred pain is, of course, due to the overflow of the stimulation received by the cells in the spinal cord from the appendix. That segment of the spinal cord from which the nerves of the appendix are derived is the same as that whence the eleventh and twelfth dorsal, and the first and second lumbar nerves arise. Where the irritation to the cord from the appendix is severe, overflow may occur even into other segments of the cord; but, as a rule, according to Sherren, referred pain occurs in the area of distribution of the eleventh dorsal nerve, less often in that of the tenth, and only rarely in that of the twelfth dorsal. Branches of the eleventh and twelfth dorsal nerves pierce the rectus muscle to supply the skin, one of these twigs being at McBurney's point, and thus explaining the very great frequency of pain and cutaneous hyperalgesia at this situation. The first lumbar nerve is distributed to the lower abdomen and upper part of the thigh, but also sends a twig to the tunica vaginalis testis, thus explaining the tenderness of the right testicle that may be met with in appendicitis. The reflex instead of being referred to sensory nerves of the skin may be referred to motor nerves supplying the muscles of the abdominal wall, the erector spinæ, the iliacus, and the psoas muscles (viscero-muscular reflex of



FIG. 9.—THE ILEO-COLIC FOSSA.

Mackenzie). As the flat muscles of the abdominal wall are not innervated by a single trunk, but by numerous twigs from different nerve trunks, where the viscero-muscular reflex from the appendix is referred only along one trunk, merely a portion of the muscle will contract; and this ribbon or band-like contraction when in the rectus muscle may readily be mistaken for an indurated and thickened appendix. When the reflex extends to the ilio-psoas muscle, flexion of the thigh is produced, and hip disease may be simulated; while vesical symptoms may be produced by spasms referred to the bladder or to its sphincter, retention or frequency of urination being the result according as the sphincter is or is not affected.

Peritoneal Fossæ.—Through the various angles and projections of the cæcum and the ileum, fossæ are formed by the reflections of the peritoneum associated with these parts of the intestinal tract; and because of their close relation with the appendix, these fossæ may play an important rôle clinically in inflammation of that organ. Lockwood and Rolleston have called special attention to these fossæ and have so carefully described them that I give their description: They are three in number: the ileo-colic, the ileo-cæcal, and the subcæcal.

The **ileo-colic fossa** (Fig. 9) is a peritoneal pouch situated in front of the mesentery in the angle formed by the junction of the ileum and colon. The floor is formed by the mesentery and sometimes also by a portion of the ileum. The ileo-colic fold of peritoneum forms the upper boundary of the fossa, and sometimes a partial roof. This pouch is variable in size and depth, and on account of its elevated position, does not play a very important part in appendicitis.

The *ileo-colic fold* is a ridge in the peritoneum of the anterior surface of the mesentery and is formed by a branch of the ileo-colic artery which runs through the ileo-colic fold and passes in front of the termination of the ileum.

The **ileo-cæcal fossa** (Fig. 10) is a peritoneal pouch situated behind the angle of junction of the ileum and cæcum. To expose it both the ileum and cæcum must be elevated. It is bounded on the right by the mesentery of the ascending colon, and on the left by the mesentery proper. The roof is formed by the *ileo-cæcal fold*, a bloodless fold of peritoneum which extends from the free



FIG. 10.—THE ILEO-CÆCAL FOLDS



border of the ileum to the cæcum and finally joins either the surface of the meso-appendix or the under surface of the mesentery near the attachment of the meso-appendix. This fossa may be very deep and long, and at times may extend upward behind the ascending colon as far as the kidney and duodenum. The mesentery of the appendix sometimes divides the fossa transversely, thus forming two fossæ, known as the superior and inferior ileo-cæcal fossæ. The ileo-cæcal fossa is important, as the appendix is usually found in relation with it, thus explaining why this location is often the site of certain products of appendicular disease. Consideration of the description of the meso-appendix and meso-cæcum induces the author to bound this fossa as follows: on the right by the cæcum, meso-cæcum, and meso-appendix; on the left, by the mesentery; and above, by the ileo-cæcal fold and the ileum.

The **subcæcal fossa** (Fig. 11), as its name implies, is immediately under the cæcum, and this portion of the bowel must be raised in order to view it. It is less constantly present than the other fossæ. Its mouth is found behind the junction of the cæcum with the colon and the fossa here separates the meso-colon into two double folds. On account of its elevated and external position, clinically it does not play a prominent part. If, however, a meso-cæcum were always present, this fossa would be a very important one, as the mouth of the fossa would then be flush with the tip of the cæcum, at the base of the appendix. Lockwood and Rolleston have described this condition as occurring, but I have never seen such a case. I prefer to describe the subcæcal fossa as a depression in the peritoneum situated beneath the cæcum, and below and external to the meso-cæcum and meso-appendix. Berry classifies these fossæ as peri-cæcal and retro-colic. Under the former term he describes the ileo-colic and the ileo-cæcal, while as retro-colic he gives an external and an internal retro-colic fossa, the latter being the more constant of the two, and apparently corresponding to that above described as the inferior ileo-cæcal fossa. It is situated, according to his description, between the inner layer of the ascending meso-colon and the posterior attachment of the mesentery, or the mesenterico-parietal fold. He bounds it thus: (1) In front: The posterior wall of the ascending colon and sometimes the cæcum. (2) Behind: The posterior abdominal wall. (3) Internally: The

mesenterico-parietal fold. (4) Externally: The internal parietocolic fold (that is, the inner layer of the ascending meso-colon). His external retro-colic fossa seems to correspond to that described here as the subcæcal.

The appendix may occupy any of these fossæ but it is commonly found in the ileo-cæcal or the subcæcal fossa. On account of the various complications that may arise if the appendix occupies any of these fossæ, the operator may be led to form an incorrect conception of the true state of affairs. Thus, at times the appendix may constitute a retro-peritoneal hernia; or, if the appendix occupy one of these fossæ, and the mouth of the fossa should close over it, the organ might be thought to be absent. Suppuration of an appendix so walled in would be entirely circumscribed.

THE FUNCTIONS OF THE APPENDIX.

The fact that the appendix can be removed without causing any demonstrable interference with the functions of the gastro-intestinal tract justifies the conclusion that the appendix is not a fundamental necessity, but does not prove that it is functionless.

The analogue of the appendix is present throughout the vertebrate kingdom, represented by a collection of lymphoid tissue in the wall of the cæcum, forming the so-called cæcal apex. It is only in the higher members of the vertebrates that this lymphoid tissue occupies a distinct structure, the appendix, differentiated from the cæcum. This differentiation is more apparent than real. Though grossly the appendix is quite different from the cæcum, yet microscopically it is seen to be composed of the same number and sort of layers, innervated and vascularized in a similar manner. As function usually parallels cellular construction it is difficult to escape the conclusion that the function of the appendix is substantially the same as that of the cæcum in which case it is not surprising that it is not indispensable. There is, however, a difference in structure which deserves mention. This has to do with the lymphoid tissue which is so prominent a part of the submucosa of the appendix particularly in the young. The cæcum is provided also with lymphoid follicles though not to the same degree as the appendix. As we usually conceive of lymphoid tissue as essentially a protective mechanism, it is possible that the appendix functionates to protect this region of the body which is richest in bacteria against invasion and injury. The fact that the appendix is so often itself inflamed does not militate against the idea since it is the part of lymphoid structures at many points in the body to receive the brunt of bacterial invasion and suffer the greatest injury. The lymphoid tissue of the appendix progressively diminishes throughout life, but never under normal circumstances disappears.

There can be no doubt that the cæcum and appendix are true functioning parts of the digestive apparatus in herbivora, and

that they are necessary for the digestion of vegetable matter. In vegetable feeders the food is only partially digested when it reaches the cæcum and appendix, where digestion is completed, the latter organs being necessary for the digestion of cellulose particularly. The cæcum is never empty but always contains a remnant of the previous meal, which is left, probably, to set up fermentation when the cæcum is refilled. In some animals, ducks for instance, there is no cæcum, but two appendices which serve the same purpose.

From these anatomical facts those who favor the view that the appendix has a function, argue that it is neither a vestigial or retrogressing organ, but a specialized, functioning portion of the intestinal canal in man.

The following clinical facts support this statement.

MacEwen observed the action of the cæcum and appendix through a wound in the outer wall of the cæcum. There was free secretion of a glairy mucus, alkaline in reaction, which became more profuse just before food entered the cæcum. The food was smeared with the secretion from the appendix and mixed with that in the cæcal cavity.

Hoefer, in repairing a wound of the cæcum, saw it undergo vigorous contractions during which a quantity of light straw-colored fluid escaped from the appendix.

Wood reported a cyst of the appendix containing six ounces of straw-colored fluid. From the history of the case it was inferred that this collection had formed in twenty-four hours.

Canal makes the statement that the appendix secretes daily six ounces of light straw-colored fluid.

These cases show that there is a definite secretion from the appendix. Taking this fact in conjunction with the structure of the appendix and its well-known usefulness in other animals, it seems reasonably certain that the normal human appendix has a definite function closely associated with cæcal digestion with protection against infection possibly.

Keith considers the evidence so strong that he thinks it probable that all the food has to pass through the appendix for complete cæcal digestion. This is hardly credible on account of the relative size of the appendix and the cæcal contents.

Metchnikoff says that not only has the appendix been preserved

long after its function has disappeared, but that the human cæcum is degenerating and the whole of the large bowel is of comparatively little use to the economy. In support of the statement that the appendix has no function he quotes Darwin's observation that all rudimentary organs show a congenital lack of the power of resistance and are frequently the seats of disease. That the cæcum is degenerating he considers evident from the fact that it is little developed in comparison with herbivora, and that in the human embryo it is relatively better developed than in the adult.

Metchnikoff also thinks that there are strong reasons for saying that the whole of the large bowel is useless and harmful, a survival from ancestors who fed on crude and rough materials. Our food now is easily digested, and except for the absorption of fluid the cæcum and large intestine have no function. He instances many cases of fistula from the lower end of the ileum completely cutting out the rest of the bowel, existing for several years without causing any interference with health. Being a reservoir of waste and putrefaction the large intestine is a manufactory of products harmful to the organism and it must therefore be regarded as an organ that has survived its period of usefulness to become "harmful to man's health and life."

These views are not necessarily dissonant. We can believe that the appendix has a function and yet that it is essentially vestigial in character and that its potentialities for harm are greater than its capability for good.

CLINICAL ÆTIOLOGY.

The ætiology of appendicitis may be appropriately divided into the clinical ætiology and the pathogenesis; the latter will be discussed in the chapter on the pathology of the affection. From the clinical point of view, the ætiological factors are either predisposing or exciting, or both.

Of the *predisposing causes*, the most important are age, sex, nationality, season, previous attacks of appendicitis, and certain other diseases. Of the *exciting causes*, the most important are exposure, disturbance of digestion, and certain other diseases. Under different circumstances, some of the latter may act as both predisposing and exciting factors.

Age is a predisposing cause of moderate importance. Although appendicitis is most common in individuals between ten and thirty years of age, about 15 per cent. of all cases occur in persons under fifteen years. The youngest patient in whom I have encountered the disease was less than one year old; the oldest, over ninety years. A case of gangrenous appendicitis found at autopsy on a seven weeks' old infant, is reported by Blumer and Shaw. Manley mentions as the youngest patient operated on a baby aged sixty-one days.¹ The marked susceptibility of young adults to appendicitis is dependent, in the first place, upon the numerous disturbances of the gastro-intestinal tract, due to dietary indiscretions, that occur during this period of life; and, secondly, to the proneness to inflammation of the adenoid tissues throughout the body during adolescence. Analogy is found in the predominance of lesions of the tonsils and of the cervical and mesenteric lymph glands during the period of development. Reason for the relative exemption from inflammation of the appendix during advanced life is found,

¹ Jackson, Am. Jour. Med. Sc., 1904, cxxvii, 710, has recorded a case of supposed *prenatal* appendicitis.

not only in a more judicious mode of life, but also in the atrophy of the adenoid tissues of the appendix. This in the majority of cases, commences at about the thirtieth year. It may, however, begin earlier or may be postponed until a later period.

Sex is a predisposing cause of considerable importance. Appendicitis was formerly thought to be very much more common in males, but recent observations tend to show that this is not the case. In a paper by Dr. Floyd W. McRae the following statistics are quoted: Einhorn, in 18,000 successive autopsies, found perforating appendicitis in 55 per cent. of males and in 57 per cent. of females; Robinson in 128 autopsies found evidences of past peritonitis on and about the appendix in 68 per cent. of female, and in 56 per cent. of male bodies. Bland-Sutton, however, is quoted as stating that appendicitis is three times as frequent in males as in females. In previous editions of this work it was stated that about 80 per cent. of all cases of appendicitis occur in males—that is to say, that it is four times as frequent in males as in females. This ratio is probably too high,¹ but we cannot accept autopsy reports as final in the records of any disease, since there are undoubtedly some cases that do not come to autopsy even if the patients die. Dr. O. Hermes is quoted in the above paper as stating that in 671 cases gathered from various sources 27 per cent. were in women; that Sonnenberg found that 40 per cent. of his cases were in women; and that of Talamon's cases 35 per cent. were in females. Hermes calculated, moreover, that of 1577 cases of appendicitis occurring in Berlin 40 per cent. were in females. McRae calls attention to the liability of abdominal pains in women being referred to the sexual organs under the vague caption of "inflammation of the tube or ovary," and he asserts that in almost all his cases the attack of appendicitis occurred at or near the menstrual period. In 15 operations for appendicitis in females, which he reports, he observed 4 cases, over 25-per cent., in which there was also distinct disease of the right tube and ovary.

¹ In the last three thousand cases of appendicitis in adults operated on by myself there were 61.87 per cent. male, 38.13 per cent. females. In the last two hundred children operated on 178 were males and 22 females, being 89 per cent. boys and 11 per cent. girls.

NINE THOUSAND OPERATIONS FOR APPENDICITIS.

I.	Sex	Acute	Chronic	Total
	Males.....	2941	1802	4743
	Females.....	1821	2436	4257
	Total.....	4762	4238	9000
	Percentage, males.....	61.76	42.52	52.7
	Percentage, females.....	38.24	57.48	47.3

II.	Age	Acute	Chronic	Total	Per cent.
	One to ten.....	247	53	300	3.33
	Eleven to twenty.....	1622	955	2577	28.63
	Twenty-one to thirty.....	1564	1809	3372	37.48
	Thirty-one to forty.....	790	937	1728	19.20
	Forty-one to fifty.....	350	370	720	8.00
	Fifty-one to sixty.....	147	89	236	2.62
	Sixty-one to seventy.....	34	24	58	0.64
	Seventy-one to eighty.....	8	1	9	0.10
	Total.....	4762	4238	9000	100.00

III.	Month	Acute	Chronic	Total	Per cent.
	January.....	358	405	763	8.48
	February.....	376	337	713	7.92
	March.....	424	424	848	9.42
	April.....	413	436	849	9.43
	May.....	455	385	846	9.33
	June.....	438	389	827	9.19
	July.....	467	402	869	9.66
	August.....	401	218	619	9.88
	September.....	376	332	708	7.87
	October.....	405	376	781	8.68
	November.....	326	287	613	6.81
	December.....	323	247	570	6.33
	Total.....	4762	4238	9000	100.00

NINE THOUSAND OPERATIONS FOR APPENDICITIS.—*Continued.*

IV.	Seasons	Acute	Chronic	Total	Per cent.
	Spring (March, April, May).....	1292	1245	2537	28.19
	Summer (June, July, August).....	1306	1009	2315	25.73
	Autumn (Sept., Oct., Nov.).....	1107	995	2102	23.34
	Winter (Dec., Jan., Feb.).....	1057	989	2046	22.74
	Total.....	4762	4238	9000	100.00

The greater attention which has recently been paid to the anatomy of the right iliac region has, moreover, convinced some surgeons that extension of inflammation from the appendix to the adnexa or from the tube and ovary to the appendix, by way of Clado's ligament and its contained structures, is considerably more frequent than was formerly supposed. Coe thinks that appendicitis in females is coincident with, or a consequence of, adnexal disease in 30 per cent. of such cases.

In view, therefore, of all these facts, it will be well perhaps to modify the statements formerly made as to the relative immunity of the female sex, and, while not, on the other hand, admitting as some would claim, that the disease in question is actually more frequent in women, to say that appendicitis occurs nearly as often in females as in males; but that it is apt to be overlooked in the former, being attributed frequently to some menstrual disturbances, or even at operation being thought secondary to tubo ovarian infection.

Karrenstein after exhaustive investigations reached the conclusion that appendicitis is equally frequent in men and in women.

Nationality is not so important an ætiological factor as it was presumed to be some time ago. It seems, however, to be of some importance; or perhaps what we consider nationality in this connection is mere environment. For a time it seemed that appendicitis was disproportionately common in the United States, the number of cases recorded in this country far exceeding those reported in Great Britain and Continental Europe. Recently, however, in France, Germany and Austria, and to a less extent in Great Britain,

the early stages of the affection have received deserved attention, and the disease is now recognized as of common occurrence. It seems, nevertheless, to be especially common in this country, and this is probably due to well-known and widespread dietetic indiscretions, particularly hurried eating and insufficient mastication. Whether those of foreign birth residing in this country who practise temperate habits of eating are less predisposed to the disease than those actively participating in all the phases of hurried American life is not definitely determined.

Season exerts little influence as an ætiological factor. Appendicitis is probably more common in Summer than it is in Spring and Autumn and Winter. The differences, however, are slight, and those that do exist are probably due to the greater frequency of intestinal disorders in Spring and Summer than in Autumn and Winter.

Of other diseases that predispose to appendicitis may be mentioned constipation, gastro-enteritis, dysentery, typhoid fever, influenza, saturnism, etc.

Constipation has by some observers been considered to play a somewhat important part in the causation of appendicitis. This causative relation is however most probably more an apparent one than a real one. In other words, the constipation and the appendicitis both have as a more remote causative factor the existence of a chronic enteritis.

Gastro-enteritis with diarrhœic attacks is probably of more importance than constipation in the ætiology of appendicitis, especially in children. Indeed, in many cases attacks of indigestion seem to be the direct exciting cause of the disease. The subacute or more chronic gastro-enteritis is probably of significance in that the appendix is prone to participate in morbid conditions that implicate the general intestinal tract. Catarrh of the intestinal mucous membrane may, and probably often does, spread to the lining of the appendix; but such is the mildness of the pathological alterations that they do not engender any clinical manifestations. At times, however, they may progress, either of their own accord or following the advent of some exciting cause, and an acute attack of appendicitis may supervene. Under other circumstances catarrhal changes of mild degree persist, and lead to chronic catarrhal or interstitial appendicitis, with

or without clinical symptoms. At all events, in many cases of chronic appendicitis careful inquiry into the past history of the patient will elicit symptoms of chronic intestinal catarrh, which either may have inaugurated, or may have been inaugurated by, the appendicitis, and which does not subside until after excision of the offending organ.

E. Franke calls attention to the findings at autopsy in a series of fatal cases of gastro-enteritis in children. He states that the appendix was invariably found to be greatly involved particularly at its distal extremity. He reached the conclusion that this condition not totally subsiding would give rise to a true appendicitis in later life.

Dysentery is also of ætiological significance, because of the predisposition of the appendix to participate in lesions of the intestinal tract. These lesions, of course, consist mainly of ulceration, and it is the consequent cicatrices that are of such extreme significance in the subsequent development of appendicitis. The significance of these cicatrices will be dealt with in the section on the pathogenesis.

Typhoid fever is one of the remote causes of appendicitis, and, at times, also one of the direct causes of the affection. It has been proved conclusively that lesions of the appendix are of common occurrence in typhoid fever. For the most part these consist of catarrhal alterations, and of swelling, congestion, and œdema of the adenoid follicles of the organ. Not uncommonly, however, ulceration occurs, and runs a course precisely similar to analogous conditions in other portions of the intestinal tract; that is, the ulceration may go on to perforation; or regeneration, organization, and cicatrization may follow the ulcerative process. As a consequence of the resultant cicatrix, more or less occlusion of the lumen of the organ may supervene, and, as will appear later, this is one of the most important factors in the subsequent development of appendicitis. In certain cases of chronic appendicitis a history of previous intestinal disorder can readily be elicited. This may consist of intestinal indigestion, vague pains in the abdomen, etc., the origin of which can often be traced to an attack of typhoid fever that may have occurred months or years previously.

This is illustrated by the following case:

Miss I. M. W. was first troubled with a mucous discharge from the bowel in the summer of 1889. At this time she had an illness which was attended

by frequent watery and sometimes bloody stools, and which was called typhoid fever. She was confined to bed for three weeks and made a tedious recovery. Since that time she has been the subject of attacks of catarrhal enteritis, which come on at intervals, the longest interval being four months. These attacks, which seem to be induced by exposure to cold, unusual exertion, sea-sickness, etc., were less frequent in the autumn and early winter, after change of air and rest during the summer, than at any other season. During the interval she was well. In June, 1893, she had an attack that lasted three weeks. When seen for the first time, vague pains were present in the right iliac fossa and a distinctly enlarged and tender appendix could be palpated. At operation there were no peritoneal adhesions, but the appendix was indurated and contained pus. The mucosa and submucosa were thickened and presented evidences of chronic catarrhal inflammation. Recovery was prompt and uneventful, and was followed by the entire disappearance of the symptoms previously complained of.

Influenza seems to exert a predisposing influence in the production of appendicitis, probably because of the intestinal lesions to which it gives rise. These changes may extend to the mucous membrane and lymphoid structures of the appendix; or such may be the swelling of the appendicular orifice produced, that drainage is effectually prevented and appendicitis results; or the influenza bacillus, gaining access to the appendix, may directly excite inflammation of this organ. Adrian found influenza bacilli in a peri-appendicular abscess. The prevalence of this disease as a pandemic may account, in part, for the great number of cases of appendicitis in recent years. Observations tending to confirm this statement have recently been recorded by Marvel, who showed that influenza and appendicitis have of late years increased almost *pari passu*. He quotes a number of authors, including Finney and Hamburger, Winternitz, Adrian, Perer, Lucas-Championnière, Schultes, and Sonnenburg, all of whom considered influenza an efficient cause of certain cases of appendicitis. Rostowzen, however, who investigated 3096 cases of appendicitis in St. Petersburg from 1890 to 1902, concludes that influenza plays but little part in its causation, and also that season has no influence upon the incidence of appendicitis.

Tonsillitis.—Kelynack is said to be the first author to report a case of fatal appendicitis following tonsillitis. Apolant, in a patient who recovered from an attack of appendicitis, thought he observed a causal relation between a preceding tonsillitis and the attack of appendicitis. Kretz records two cases of appendicitis, in

the first of which, in a young woman, he obtained streptococci from both the appendix and the tonsils; and in the second case, in a young man, he recovered streptococci from the appendix, and influenza bacilli as well as streptococci from the tonsils. Weber has reported three cases of appendicitis following angina; and, in reviewing the literature, refers to similar cases recorded by Brazil, Routier, Simonin, Schnitzler, and Rudolph, as well as by the other authors mentioned above. Mayer has recently recorded a case of gangrenous pharyngitis followed by appendicitis.

Some two years since the following case came under my observation:

A girl, aged seven years, had been taken sick ten days previously with sore throat, difficulty in swallowing, high fever and so forth. The attending physician the day following the onset found patches upon the throat which, when examined bacteriologically, showed the diphtheria bacillus. The patient recovered under the administration of antitoxin, when at the end of a week she was seized with acute abdominal pain followed by abscess formation in the appendiceal region. Three days later I saw the girl in consultation and advised simple evacuation of the collection, which presented well toward the crest of the ilium. This was done under ether anæsthesia, from which the patient reacted very satisfactorily. At the end of the second day the patient died suddenly, death being attributed to diphtheritic paralysis of the heart.

Rheumatism has been assumed by some to be a causative factor in the production of appendicitis and several cases of rheumatic appendicitis have been reported. As the evidence at hand seems to indicate that rheumatism is either an infection or an intoxication, it is not unlikely that the organism provocative of the articular alterations may inaugurate disease of the appendix. The probability of this is further enhanced because of the predilection of the rheumatic infective agent for certain adenoid tissues, such as those of the tonsils, and by analogy also the tissues of the appendix. Personally, however, I have never encountered a case in which rheumatism and appendicitis were associated.

Goodhart mentions a frequent stomach-ache as a "feature of the rheumatic child." Sutherland notes the association between appendicitis and rheumatic symptoms in two cases of boys of eight and nine years, respectively. Sir James Grant reports a case of appendicitis following persistent pains in the feet and followed by acute

rheumatic fever. Haig reports cases of rheumatic typhlitis, which he apparently considers the same as retrocedent gout. He found that salicylates had a marvelous effect in allaying the pain. Yeo and Brazil each report a similar case of appendicitis associated with rheumatism. Sutherland considers the association of the two diseases commoner in children than adults. Besides the cases referred to above, he here adds 6 more, in children from six to twelve years, who had attacks of appendicitis accompanied by acute rheumatic fever, endocarditis, or tonsillitis. Other cases of like nature are those reported by Poynton, and by Finney and Hamburger. The latter authors refer also to a case reported by Pribram. Adrian, Goluboff, and Gagnières have contributed further articles to the literature of appendicitis considered as a local manifestation of a general disease.

Various Infectious Diseases.—Jalaguier saw appendicitis follow measles, chicken-pox, scarlet fever, and mumps, as well as typhoid fever and acute articular rheumatism. Tripier and Paviot observed perforative appendicitis following, and in their opinion caused by, an infected bullet wound of the forearm.

Purpura hæmorrhagica has been held responsible for the onset of symptoms of appendicitis, in a case recorded by N. Jacobson. He cites other cases of purpura hæmorrhagica with intestinal hæmorrhage. Box and Wallace observed a case mistaken for typhoid fever, because of the intestinal hæmorrhage, but found at autopsy to be one of suppurative appendicitis, with no lesions in other parts of the intestinal tract. There was no evidence here of purpura.

The most important predisposing cause of appendicitis is the fact that the appendix has already been the seat of **one or more attacks of the same affection**. The reasons for this will be discussed more in detail in the section on the pathogenesis. Clinically, the fact is well established that those who have had one attack of appendicitis are most likely to suffer from others. Among my own cases, a history of a previous attack could be obtained in nearly 85 per cent.

Of the **exciting causes of appendicitis**, from the clinical point of view, **disturbances of digestion** are the most important. Such is the pre-eminence of these in the ætiology of appendicitis, and with such constancy have they been observed, that it is un-

hesitatingly asserted that appropriate inquiry will elicit a history of such disturbances in almost all cases. The alterations induced by or causing the acute indigestion may spread to the appendix, and, causing swelling of the mucous membrane, may prevent drainage and lead to appendicitis. When the digestion is faulty the bacterial flora of the intestine may be much increased and pathogenic organisms be present in abundance. The catarrhal conditions which are then engendered also offer less opposition to bacterial invasion than does the healthy mucous membrane. In this connection however it must be remembered that indigestion is quite as often the result of disease of the appendix as the reverse.

That **exposure to inclement weather** and to other deleterious influences acts as an exciting cause of appendicitis cannot be doubted. The connection between the exposure and the development of the appendicitis is most clear and direct, and must be accepted as clinically important.

Traumatism had been given by many authors as an exciting cause of appendicitis and many of the cases apparently being authentic. Sonnenberg and Deaver have collected many of the instances. In a careful search of histories of 500 cases of acute appendicitis there was no evidence of traumatism as a causative factor and in my whole experience I have never encountered an undoubted instance of appendicitis caused by trauma.

Of other diseases that act as exciting causes of appendicitis may be mentioned typhoid fever, dysentery, tuberculosis, actinomycosis, etc. The ordinary lesions of the appendix in **typhoid fever** have already received attention. The ulceration may progress, and may lead, with or without perforation, to appendicular peritonitis, and, as a consequence, to the ordinary manifestations of appendicitis with peritonitis. Such are the diagnostic difficulties presented by some of these cases that the question of the presence of typhoid fever or appendicitis, or of one as a complication of the other, cannot be decided without recourse to operation.

Dysentery rarely leads directly to the development of acute appendicitis, but the possibility of its occurrence should be borne in mind. The relation of **tuberculosis** and **actinomycosis** to the development of appendicitis will be discussed in the section on Pathology.

Intestinal parasites have been held responsible for attacks of appendicitis by Metchnikoff, who mentions four cases in which recurrent attacks of appendicitis ceased after lumbricoids had been expelled by the action of vermifuges. He refers to Becquerel, who, over sixty years ago, found at autopsy an appendix perforated by lumbricoids. Other cases, Metchnikoff says, have been reported by Natale, Brun, Guinard, and Girard. Bloodgood reports a case of appendiceal abscess from perforation by round worms, the abscess being localized between the layers of the ileac mesentery; while Rammstadt observed a case of appendicitis caused by the presence of the oxyuris.

PATHOLOGY.

A just conception of the nature of appendicitis, as of other diseases, is, of course, not possible from a study of the pathological characteristics of its terminal stages alone; to be reliably informed of its pathogenesis especial attention must be directed also to the alterations that occur in the very inception of the disease. It is to the infrequency of death in the early stages of appendicitis, to its non-occurrence in mild cases, and the consequent lack of opportunity for the study of the early and mild pathological conditions, that the older and erroneous views with regard to the affection then recognized as typhlitis, perityphlitis, etc., may be attributed. It is only at a comparatively recent date that the true nature of inflammations of the right iliac fossa has been determined, and this largely through the investigation of diseased appendices removed by early operation.

The classification of appendicitis has long been a moot subject. Naturally it must vary with the basis of classification adopted—ætiological, anatomical, or clinical. Ætiologically appendicitis is an infectious process—the consequence of bacterial infection of the appendix. One may well doubt that a case of appendicitis ever occurs independently of the operations of bacteria; even in cases following trauma, animal parasitic invasion of the appendix, interference with the blood supply (by means of twists, angulations, or adhesions), etc., bacteria are the active agents in causing the inflammatory lesions. An amplification of the ætiological classification suggests such terms as bacterium coli infection, streptococcic infection, staphylococcic infection, pneumococcic infection of the appendix, etc. Doubtless in some cases these different infective agents give rise to varying clinical manifestations, but at present these are scarcely susceptible of clinical differentiation. It is likely, however, that the future may enable us to make such differentiation—by means of certain at present ill-observed clinical manifestations, by serum reactions and other laboratory methods, etc. For the present, however, all that can be said is that ætiologically appendicitis is an infectious process.

Anatomically, as well as clinically, two varieties of inflammation of the vermiform appendix may be recognized—an acute and a chronic appendicitis. Like inflammation elsewhere in the body, the inflammatory manifestations in the appendix may commence acutely or chronically. If the former be the case, the acute manifestations may subside after a greater or less interval of time, and the pathological alterations may persist as a chronic inflammation. Thus, chronic inflammation may be the residual manifestation of a previous acute inflammation, or the condition may begin as a chronic inflammation. Of the acute and chronic forms of appendicitis, several varieties may be distinguished, and for purposes of anatomical and histological study it is deemed advisable to adopt some rational classification. The following pathologico-anatomical classification, based upon the results of this investigation, but which does not differ essentially from several that have already been proposed, is suggested:

Acute Appendicitis:

1. Catarrhal.
2. Interstitial.
3. Ulcerative.
 - (a) Non-perforative.
 - (b) Perforative.
4. Gangrenous.

Chronic Appendicitis:

1. Catarrhal.
2. Interstitial.
3. Obliterating.

This classification, which is anatomically well founded, as it indicates the nature of the lesions of the appendix, is not in contravention of the clinical course of the disease. It must be candidly admitted, however, that we are not always able to distinguish clinically the different pathologico-anatomical varieties of appendicitis. In other words, the different pathologico-anatomical varieties of the affection may present analogous clinical manifestations. Again, the severity of the clinical manifestations of an individual attack of appendicitis frequently bears no relation to the seriousness of the lesions of the appendix, nor is the number of attacks always a trustworthy index of the condition of the appendix. And, further, it

may be said that often the different varieties of both acute and chronic appendicitis are but stages of a single pathological process. An inflammation of the appendix, originating as a catarrh, may, in a given instance, progress to the interstitial variety. This in turn may be succeeded by ulceration which, depending upon a variety of circumstances, may or may not lead to perforation of the organ. Gangrenous appendicitis may also follow in such a train of events, though it not infrequently arises in a totally different manner. Similarly, chronic interstitial appendicitis may follow that process which began as a chronic catarrh, and not the least interesting, if not the most common, form of this chronic inflammation of the appendix is the obliterating variety. Again, an appendix that for a longer or shorter period of time has been the seat of chronic inflammation may suddenly suffer an acute exacerbation, and may present the most intense degrees of acute interstitial inflammation, with suppuration, ulceration, or gangrene, and well-marked and fatal peritonitis. On the other hand, a severe attack of appendicitis may be partially recovered from, and may be succeeded by several much milder attacks. Indeed, an acute exacerbation of the lesions of a chronically inflamed appendix is one of the most likely of events. The majority of cases of chronic appendicitis are those in which the appendix has been the seat not only of a chronic inflammation, but also of recurring attacks of more or less acuteness—cases designated clinically as recurring or relapsing appendicitis. In addition, the inflammatory phenomena in different appendices vary with respect to the situation and extent of the lesions and the rapidity of their progress; and these are not uninfluenced by the possibly persisting consequences of previous inflammation. Furthermore, the most diverse peritoneal lesions may be associated with different cases of the same variety of appendicitis.

The foregoing classification, based, as it is, upon the nature and character of the lesions occurring in the several varieties of appendicitis, seems more appropriate than those which comprise such terms as "simple," "mild," "perforating," "infective," etc. "Simple" and "mild," as a rule, are used merely to indicate the severity of the clinical manifestations, and, as already stated, this is often no index to the seriousness of the lesions of the appendix, although, of course, "mild" lesions do occur. "Perforative" merely indicates

an accident that may or may not happen in the course of ulcerative and gangrenous appendicitis. The reservation of the term "infective" to designate certain cases only of appendicitis is inappropriate; for, as has been stated and as will be seen later, all cases of appendicitis must be attributed to the pathogenetic activities of bacteria.

The pathology of inflammation of the vermiform appendix will be discussed as follows:

1. *The Lesions of the Appendix.*
2. *The Peritonitis and its Consequences.*
3. *The Bacteriology.*
4. *The Pathogenesis.*

THE LESIONS OF THE APPENDIX.

ACUTE APPENDICITIS.

ACUTE CATARRHAL APPENDICITIS.

By acute catarrhal appendicitis is understood that variety of acute inflammation of the appendix in which the pathological alterations are wholly or almost wholly confined to the mucous membrane, the other coats of the organ presenting but little or no deviation from the normal. In this connection the term catarrhal is employed strictly within its pathological significance. Implying, as it does, a superficial inflammation limited to the mucous membrane, it is certainly incorrect to apply it, as has been done, to inflammatory conditions of the appendix in which the lesions involve the deeper layers of the wall of the organ.

That this variety of appendicitis does occur there can be no question. It is not true, as has been held by Talamon and others, that in every case of inflammation of the appendix all the coats

NOTE.—The percentages in this article are derived from Dr. A. O. J. Kelly's original work for the second and third editions, and we have found that what he there stated is still true, and though a continued systematic microscopic examination of all appendices removed by Dr. Deaver has been made (from January 8, 1906—appendix No. 3097) to the present date (September 1, 1912—appendix No. 8718), yet our conviction is that a further elaboration of a greater number of cases would not have materially altered the percentages. Dr. Kelly's original deductions were drawn from the most careful study of 577 cases. In this volume, in an effort to save space, only the percentages will be given and the reader is referred to the Third Edition for the more complete statistics.

are involved, or that, at least, the inflammatory alterations extend to and implicate the muscular coats. Nor can I agree with Kelynack and others who consider the term catarrhal most open to objection because of its suggesting a superficial inflammation—they thereby implying that such a condition does not occur in the appendix.

Acute catarrhal appendicitis is probably not uncommon. It doubtless often gives rise to but few clinical manifestations, and, most likely, under some circumstances to none at all, as, for instance, if the lumen of the organ be of good calibre. This opinion is borne out by the many instances of catarrhal inflammation of the appendix disclosed by systematic examination of a large number of appendices removed postmortem from those who during life presented no clinical manifestations of such disease. In many of these cases the lesions are strictly confined to the mucous membrane. That this variety of appendicitis, however, is infrequently met at operation is indicated by the fact that of 239 cases of acute appendicitis that were investigated, but 9 were of the catarrhal variety. It is quite likely, nevertheless, that if many of the appendices which when deranged give rise to very mild clinical symptoms were examined microscopically, they would reveal evidences of catarrhal inflammation. It is likely, also, that this variety of appendicitis constitutes the early stage of many cases of the more severe varieties of acute inflammation, and it is doubtless commonly the starting-point of many of the chronic cases.

Macroscopy.—In this variety of appendicitis, to the naked eye the general configuration and external appearances of the organ are not appreciably altered, although it may feel a little stiffer or firmer to the touch. The mucous membrane is swollen, hyperæmic, and œdematous. The lumen of the organ may be partially or completely occluded at one point or at several points, and this is the more likely to be the case, the narrower the lumen prior to the attack of inflammation and the more intense the inflammation. The mucous membrane is covered with a secretion that partly or completely fills the lumen of the organ if it be patulous. This secretion is variable in amount and character. It may be abundant or meagre, depending to a considerable extent upon the intensity of the inflammation (and whether or not the catarrhal alterations are associated with more widespread lesions). In character it

may be clear and mucous, turbid, grayish or yellowish-green, or brownish and purulent; or sanguinolent; or a combination of any of these. The contents of the appendix vary, depending upon whether they consist solely of such secretion, or of such secretion combined with more or less fæcal matter. They may be fluid or semi-fluid, or they may approach the consistency of inspissated fæcal matter. In this variety of appendicitis I have not encountered any true appendicular calculi. The odor of the contents is also variable. It is commonly distinctly fæcal in character, with different degrees of malodorousness. Occasionally the lymphoid follicles appear enlarged. The crypts of Lieberkühn can usually be detected, being distinctly distended, commonly with a grayish or a grayish-yellow secretion. If the inflammation be rather intense and, as is the rule, the lesions extend beyond the mucosa, the secretion is likely to be distinctly purulent; hence the designation, *purulent catarrhal appendicitis*. Under such circumstances slight superficial erosion and desquamation of the epithelium of the mucous membrane may supervene, and if the inflammation be still more intense, rupture of minute vessels in the lowermost layers of the mucosa may occur. The hæmorrhagic foci that thus ensue have lead to the designation *hæmorrhagic catarrhal appendicitis*. These various lesions may extend uniformly throughout the length of the appendix, or they may be relatively intense in one portion and comparatively inconspicuous in others. Indeed, certain regions may be entirely unaffected.

Microscopy.—Upon microscopical examination of such appendices the crypts of Lieberkühn are found distended to a variable degree. Usually the contents are of the well-known mucous nature; occasionally, however, they are muco-purulent, purulent, or hæmorrhagic—in the event of which the lesions usually extend beyond the mucosa. The individual epithelial cells of these crypts, as well as those of the surface epithelium, are swollen, distorted, and occupied by a clear, translucent, spheroid, or ovoid droplet which, situated toward the free extremity of the cell, displaces the cell protoplasm and the nucleus downward or somewhat to one side. This droplet reveals the characteristics of mucin generally, and is commonly elaborated without destruction of the cell body. After the discharge of this droplet the cells reveal the characteristic

goblet appearance, and subsequently they may assume their normal configuration and appearance. Some emigrated leucocytes are usually visible between the epithelial cells, and the entire mucosa is the seat of more or less serous infiltration. Besides these alterations and some congestion of the vessels of the mucosa and submucosa the mild forms of this variety of inflammation of the appendix may present no noteworthy pathological features. If, however, the inflammation be more intense, in addition to the foregoing changes there are noticeable a more marked congestion of the vessels of the mucosa and submucosa, a greater degree of serous infiltration, a more marked infiltration of the retiform tissue of the mucous membrane with emigrated leucocytes, some cellular proliferation and desquamation of the epithelial cells of the crypts of Lieberkühn and of those lining the lumen of the appendix. The difference between this and acute interstitial appendicitis is one of degree only, and all gradations are encountered. In some of the severer cases the cellular exudate becomes more excessive, and gives rise to marked swelling of the mucous membrane and to pressure upon the crypts of Lieberkühn. Partly because of this, and also because of the desquamation of their epithelial lining, some of these crypts become obliterated. Under such circumstances the cellular exudate reaches the surface of the lumen, and being cast off, commingled with desquamated epithelial cells, excessive mucus, and granular débris, constitutes the microscopical evidence of what has been termed *purulent catarrhal appendicitis*. The contents of the lumen are composed of similar matter. The desquamation of the epithelial cells may occur slowly or rapidly, and the cells desquamated may be in a good state of preservation or they may be already partly or completely necrotic, or the seat of serous or mucous infiltration. If the inflammation be still more intense, the alterations already described become more marked, and there may occur some diapedesis of erythrocytes. Indeed, in a small number of cases minute hæmorrhagic foci may be detected—*hæmorrhagic catarrhal appendicitis*. Noeggerath asserts on experimental grounds that such minute hæmorrhagic foci are usually traumatic, and Letulle supports this statement and asserts that such hæmorrhages are often demonstrable in the entire absence of any signs of inflammation of the appendix. In view of these

investigations it would seem probable that at least some of the hæmorrhages of this nature have been caused by the trauma incident to the removal of the appendix. In all cases of catarrhal appendicitis, excluding possibly the very mildest forms, there is some swelling, congestion, and serous infiltration of the lymph nodules.

The further course of such catarrhal appendicitis is one of three: In a very few instances it is possible that, if the lesions be very slight, a complete restoration of the mucous membrane to its former condition may take place. The contents of the appendix are discharged into the cæcum, the congestion and swelling of the mucous membrane subside, the leucocytic infiltration and the cellular exudate are absorbed, and desquamated and eroded epithelial cells are replaced by newly formed cells. The likelihood of such *restitutio ad integrum* is influenced by the cause of the inflammation, the free and thorough drainage of the organ, and the character and virulence of the micro-organisms present. Analogy and some facts warrant us in supposing that such mild catarrhal appendicitis is more common than is generally thought, that clinical manifestations are often slight or entirely absent, and that in some such instances the appendices return to their previously normal condition. However, in the majority of cases in which the lesions are sufficiently intense to give rise to clinical manifestations, and in all cases in which the previously detailed pathological alterations are at all marked, the return of the appendix to its normal condition is not possible. The acute manifestations either partly subside and become chronic, or they become more intense, more generalized, and lead to some of the severer forms of appendicitis. This latter is a very likely event, not only because of the natural tendency of the disease, but also because of the liberal lymphatic supply of the appendix, whereby the noxious agents provocative of the lesions of the mucous membrane readily gain access to, and implicate the deeper layers of, the wall of the organ.

ACUTE INTERSTITIAL APPENDICITIS.

By acute interstitial appendicitis is understood that variety of acute inflammation of the appendix in which the pathological alterations extend throughout and involve all the coats of the

organ. An inflammation of the appendix may implicate all the coats of the organ from the outset, but, as already stated, it is not unlikely that catarrhal alterations inaugurate the process in a considerable number of cases. The extensive lymphatic supply of the organ furnishes a ready means for the rapid dispersion of the agents causing the inflammation, thus engendering the generalization of the process. That this form of appendicitis is more common than the catarrhal variety, or at least gives rise to clinical manifestations more frequently is indicated by the fact that of 239 cases of acute appendicitis examined, 38 were of the interstitial variety. In this form the pathological alterations are commonly more intense in one coat than in others, and they vary also in different regions of the same coat.

Macroscopy.—To the naked eye the appendix appears swollen, oedematous, and reddened; and injection of many of the vessels beneath the peritoneal covering can commonly be distinctly detected. If the inflammation be of minor grade, the organ is quite firm to the touch; but if it be either moderate or intense, the appendix often seems softer than normal. The mucous membrane is swollen, hyperæmic, oedematous, and softened, and the entire wall of the organ appears thicker than normal. The mucous membrane is more likely to reveal minute hæmorrhages than in catarrhal appendicitis. Occlusion of the lumen in one or more places is common. If it be patulous, the contents are muco-purulent, purulent or hæmorrhagic and they are more likely to be the last named, and also to be very malodorous, in this than in the catarrhal variety. The other macroscopical appearances do not differ materially from those described in connection with the catarrhal variety (with which it is usually associated), though the swelling of the lymphoid follicles is more likely to be conspicuous. Appendicular calculi were found in 6.2 per cent. of the appendices examined.

Microscopy.—Upon microscopical examination the pathological alterations described in connection with the microscopy of catarrhal appendicitis are evident. They are, however, commonly more marked in degree. The crypts of Lieberkühn are often almost completely obliterated, there is dense cellular infiltration of the retiform tissue of the mucous membrane, and the latter is not

infrequently represented by a dense aggregation of small round cells which extend to the free edge, and in which remnants of degenerated epithelial cells and crypts of Lieberkühn are discernible. In addition, the pathological alterations have extended to, and more or less extensively involve, the submucous, muscular, and subserous coats. Throughout the submucous and muscular coats there are a variable amount of dilatation of the blood-vessels, some serous infiltration, and a more or less dense collection of small round cells. At times these small round cells infiltrate more or less diffusely one or all of the layers of the wall of the appendix, causing separation of the fibrillar and muscular bundles and constituting a veritable *purulent* or *phlegmonous infiltration* or *suppuration of the appendix*. On the other hand, these small round cells may be congregated into smaller, or larger masses, forming circumscribed abscesses—*interstitial abscesses*—in various regions of the organ. While the diffuse infiltration is more likely to predominate in the muscular layers, the small, circumscribed abscesses show a predilection for the submucous and subserous layers. No definite rules, however, can be laid down for these. The leucocytic infiltration is especially conspicuous about the blood-vessels, but evidences of productive inflammatory alterations are common elsewhere. In cases of moderate and more intense inflammation hæmorrhagic foci are relatively common. At times these are small; at times, however, they are very extensive, and give rise to more or less widespread destruction of tissue.

A conspicuous feature of this, as well as of the more severe varieties of appendicitis, is the involvement of the lymphoid elements. These are commonly swollen and are generally the seat of serous infiltration. The capillaries and lymph spaces appear distended—the former filled with blood corpuscles, the latter with lymph corpuscles, leucocytes, and sometimes erythrocytes—and into their lumens there project proliferating endothelial cells. At times the latter desquamate, and thus assist in occluding the distended spaces. There also occur an infiltration of the nodules with leucocytes and an active proliferation of the cells of the reticulum. In the immediate vicinity of these lymphoid follicles there are often small collections of lymphoid cells; these should not be confounded with the results of productive inflammation, which also abound. In the more advanced stages of the inflammation

these lymphoid follicles undergo various retrograde changes. They commonly become necrotic, the necrosis arising in one of two ways: it may commence in or about the centre of the follicle, and more or less rapidly involve the entire nodule; or small scattered foci of necrosis may simultaneously, or almost simultaneously, arise in different portions of the follicle, and, finally, either become confluent or remain discrete. It has seemed to me that the latter form of necrosis is the more common. At first the nuclei of the lymphoid cells, and later those of the reticulum, refuse to stain well. They appear indistinct and blurred, and their edges become ragged. Subsequently hyperchromatosis, chromatolysis, or karyorrhexis supervenes, and plasmolysis follows or occurs coincidentally. Finally, the focus undergoes complete liquefaction. Neighboring areas become similarly affected, and several adjoining foci may become confluent and form larger ones. The exudated polynuclear leucocytes participate in the process and speedily become liquefied. The reticulum, sometimes at first homogeneous, later becomes granular and liquefies. There thus develops within the wall of the appendix, without of necessity any solution of the continuity of the mucous membrane or of the serous coat developing, a focus or several foci of softening which, in the later stages at least, consist largely of purulent matter—*follicular abscess*. This commonly ruptures into the lumen of the appendix, and there is thus produced a form of ulcerative appendicitis, of which mention will be made subsequently. Hæmorrhage sometimes occurs into these foci of softening, and around them, at times, various deposits of blood pigment are discernible.

The pathological anatomy of this, as well as of the ulcerative, form of appendicitis varies somewhat, depending upon the possibly persisting consequences of previous inflammation. At times, as a result of previous acute or chronic inflammation, strictures, angulations, or flexures may have formed, obstructing the lumen of the organ. Under such circumstances the appendix may be divided into two or more compartments, and each of these may present pathological alterations different from the others. One portion may reveal only catarrhal inflammation; another, in addition to this, rather marked interstitial inflammation; while, under some circumstances, another portion may be practically unaffected.

The proximal portion is the most likely to present no deviations from the normal. The tip, on the other hand, is not infrequently seriously involved, being distended and filled with clear or turbid fluid or with pus. The contents of the distended portion may be purulent from the commencement of the inflammation, or there may occur a purulent metamorphosis of previously clear fluid. This condition, in which the lumen of the appendix has been converted into a closed cavity and is filled with pus, is spoken of as *empyema of the appendix*. Under these circumstances the wall of the appendix constitutes the wall of the empyema or abscess cavity. The development of an empyema of the appendix presupposes a stenosis or complete occlusion of the lumen, and this may be brought about by twists or angulations of the organ, internal cicatrices resulting from previous inflammation, or external cicatrizing bands of adhesions. The stenosis or occlusion of the lumen may occur at any point along the appendix, and in consequence the empyema may involve the entire organ or only part of it. We thus speak of a partial or complete empyema, as the case may be. The empyema may develop slowly or rapidly, and it may be rather small or may attain a considerable size. It commonly occurs in connection with acute inflammation, but that it also develops in association with some cases of chronic inflammation (a few of them possibly tuberculous), and with acute exacerbations of chronic inflammations, is well established. Although in its initial stages this condition of empyema may be present without appreciable ulceration of the appendix—that is, it may be associated with catarrhal and interstitial appendicitis, with intact basement membrane—from its very nature it forms a transition stage to ulceration of the appendix, and is commonly found in connection therewith. If such an appendix be not removed by operation, there occur serous and cellular infiltration and necrosis of the wall of the organ, excessive distention, perforation, and peritonitis. The final process is similar to ulcerative appendicitis.

It is not possible for the interstitial variety of appendicitis to eventuate in the restoration of the organ to its previous healthy condition. If the pathological alterations are slight or moderate in degree, and if there are productive connective tissue changes rather than polynuclear leucocytic infiltration, the acute mani-

festations may subside and a variety of chronic appendicitis may result. It is much more likely, however, if the appendix is not excised or the patient does not die, that the pathological changes will progress to necrosis and ulceration.

ACUTE ULCERATIVE APPENDICITIS.

By acute ulcerative appendicitis is understood that variety of acute inflammation of the appendix in which there occurs a liquefaction necrosis of the inflammatory exudate and of more or less of the wall of the organ in communication with its lumen. This is naturally but an aggravation of the previously described forms of appendicitis, and both the catarrhal and interstitial varieties may present gradual progression to it. It is possible, however, for ulcerative appendicitis to arise without previous catarrh; it may be due to septic infection, typhoid fever, dysentery, etc. Two forms may be distinguished—a non-perforative and a perforative. One is but an aggravation of the other—perforation being an accident that may or may not occur in the course of the affection. That this variety of appendicitis is relatively common is indicated by the fact that of 239 cases of acute appendicitis examined, 142 were of the ulcerative variety—68 being non-perforative and 74 perforative.

Macroscopy.—To the unaided eye the appendix is swollen, œdematous, excessively congested, and may seem a little firmer to the touch than normal, in consequence of the tension of the peritoneal covering. In the event, however, of perforation, or of perforation being imminent, the area of such impending or actual perforation can readily be distinguished by its being softer than the surrounding tissue. The swelling and œdema vary in different portions. Usually, they are very irregularly distributed, being more marked in one region than in another. In places the seat of serious disease the appendix may be as thick as a finger or thicker, whereas other portions may be not thicker than a lead-pencil and almost normal in appearance. Certain regions may present merely dilatation of the blood-vessels, the larger ones being distinctly distended, while those ordinarily invisible to the unaided eye are readily perceptible. In other portions there may be a diffuse redness, varying in shade from an intense bright redness to a deep reddish-blue or

purplish color. If perforation be imminent, the area involved is usually of a brownish-green or blackish-green color, and is softer and more prominent than the adjoining region. It is closely surrounded by an area of intense bright redness, and is usually covered by some discolored exudate. There may be only one of these spots of impending perforation or there may be several of them, and they may be situated anywhere along the course of the appendix. Such spots are most frequently found opposite the attachment of the meso-appendix. Not uncommonly, however, they are near the attachment of the meso-appendix, and sometimes they are encountered between the two layers of this structure. Several of these may apparently coalesce to form larger areas. Under such circumstances perforation of the wall of the appendix is most likely to ensue. The perforation may be exceedingly small—scarcely perceptible; or it may be large enough to admit a straw or a goose-quill; or, exceptionally, it may be upward of a centimetre in extent. Perforations more than a centimetre in size are very uncommon, unless as a result of circular amputation or of widespread gangrene of the organ. There may be only one perforation or there may be several, varying in size and situation. They may be close together or quite removed from one another. Although, as a rule, the perforation occurs in the centre of the previously mentioned spot of discoloration, such spots may individually reveal several perforations. The perforation is usually round, but it may be ovoid, elongated, or without definite outline. If irregular, it may course in the direction of the long or transverse axis of the organ or diagonally. The edges are usually very ragged.

Perforation of the appendix is considered to have occurred when communication has been established between the exterior of the organ and its lumen. In contradistinction to this, it not infrequently happens that a circumscribed abscess in the wall of the appendix ruptures externally—that is, through the serous coat—without a communication being established with the lumen. In the event of true perforation, conditions are favorable for the escape of faecal matter from the lumen of the appendix into the peritoneal cavity; in the other variety of perforation, or rupture of a portion of the wall, such an accident does not occur.

The contents of the lumen in ulcerative appendicitis vary but slightly; they may be muco-purulent, though they are commonly

distinctly purulent, with more or less admixture of fæcal matter, and very malodorous. On the other hand, if perforation has occurred, the lumen may be practically empty. The wall of the appendix is thickened, especially at the seat of most manifest disease. On the inner aspect marked alterations of the lining membrane and a variable number of ulcers are seen. That portion of the mucous membrane which is not ulcerated is much swollen, congested, softened, and commonly presents minute hæmorrhagic foci. Often, however, the entire mucous membrane is yellowish-green, much discolored, and resembles a false membrane. At times there is a single ulcer; at times several that vary in size and situation. The ulcers may be situated anywhere along the length or circumference of the organ. They usually correspond in location to the areas of discoloration visible on the external aspect, though some ulcers, particularly if they be superficial, may reveal no external indications of their presence. They are rather common opposite the attachment of the meso-appendix, probably because in this situation the blood supply is poorest. These ulcers may be round, ovoid, elongated, or irregular in outline. They may involve one, two, three, or all of the coats of the appendix. They usually have sloping edges, in that the greatest destruction of tissue is at the surface—the mucous membrane. At times, however, and not infrequently in the early stages, excessive swelling and œdema of the tissues obscure or completely efface this character of the ulcer. It is merely a question of the severity of the pathological lesions, and to some extent also of the duration of the disease, whether the ulcerative condition goes on to perforation or not. Many cases of non-perforative ulcerative appendicitis in which the appendix is excised early would, if operation were deferred, progress to perforation. The surface of the ulcer is usually intensely red. Not uncommonly, however, it is of a greenish-yellow or greenish-black color, and is covered with discolored purulent or purulent fæcal matter; when this is removed by irrigation, the surface of the ulcer is seen to be the seat of hæmorrhagic suffusion. If perforation has occurred, the ragged edges of the opening are also visible. In the neighborhood of the ulceration—or, more particularly, of the perforation, if this has occurred—an appendicular calculus may be detected. Not infrequently this will be found occupying a site directly over the ulceration; often enough, however;

just above, and less commonly below, the latter. Exceptionally, it will be found within the perforation, partly or completely occluding it, and in a fair proportion of cases of perforation diligent search will often be rewarded by the discovery of the calculus in the exudate or pus surrounding the appendix.

Although it is generally held that appendicular calculi—otherwise spoken of as fæcal concretions—are common in this variety of appendicitis, statistics differ widely as to the frequency of their occurrence. They were found in 28 (22.3 per cent.) of 120 of the cases that I examined. Of these 120 cases, 56 were non-perforative, and calculi were found in 9 (16 per cent.); 64 were perforative, and calculi were found in 19 (29.8 per cent.). There can hardly be much question, however, that they are more frequently present than these latter figures indicate. The foregoing statistics include only those cases in which the calculus was detected in the appendix when it was examined in the laboratory.

Reference has been made to the fact that in certain cases of ulcerative appendicitis with perforation the calculus may have escaped from the appendix before the time of operation or necropsy; in these cases its presence may be undetected at the subsequent examination. There is thus no doubt that the foregoing figures do not indicate the exact frequency of calculi in ulcerative appendicitis with perforation. On the other hand, it is believed that more or less inspissated fæcal matter has been classed by some surgeons as fæcal concretions, and that this fact serves to indicate in their statistics a greater frequency of calculi than is actually the case. Such inspissated fæcal matter is quite common, but in this statistical study of the subject has been ignored, only well-formed calculi being considered.

Perforation of the appendix results from the direct necrotic action of bacteria and their toxins, or from the mechanical action of calculi, or from the combined action of both. Exceptionally, it results from the bursting of an empyema, but under such circumstances the rupture is not unconnected with the activities of bacteria. Perforation of the organ is favored by anæmia, due to withdrawal of the proper blood supply. This may be the consequence of twists, flexures, or angulations of the organ; of the action of external cicatricial bands of adhesions; of thrombo-arteritis or thrombo-phlebitis; or of a combination of any of these factors. Predominance

in causing perforation of the appendix must, however, be accorded bacteria. Calculi, nevertheless, are of considerable significance; but it is not warrantable to state that they must have been operative in all cases, assuming in those cases in which they were not found that they must have been overlooked or must have become disintegrated in the pus or exudate. They are often of decisive importance in determining the *site* of the perforation.

Perforation of the appendix may occur into preformed peritoneal adhesions, and give rise to a circumscribed peri-appendicular abscess. If, however, the perforation ensue very early in the course of the affection, before the peritoneum has had time to set up reactive adhesions, the contents of the appendix are evacuated into the general peritoneal cavity, and there results a diffusing peritonitis, of which mention will be made subsequently. Again, perforation may occur into the meso-appendix, and the contents of the appendix, liberated and dissecting up the two layers of this structure, may eventually reach the retro-peritoneal connective tissue and there produce a retro-peritoneal abscess. Under some circumstances the appendix has formed attachments with various organs, and, in the event of perforation of the appendix, the ulcerative process may continue also into these. If the organ in question be hollow, the ulcerative process, invading first the superficial layers of the appendix, finally its serous coat, then the serous coat of the hollow organ (intestine), until ultimately its mucous coat is perforated, produces a *bimucous fistula*. As it is the cæcum with which the appendix most frequently forms adhesions, so also is it the cæcum that is most frequently perforated in this manner. But cases have been reported in which perforation occurred into the duodenum and other portions of the intestinal tract. In addition, Keen, Bossard, Dalmer and Pilcher report cases in which perforation occurred into the bladder. In Keen's and Pilcher's cases the appendix became permanently adherent to the bladder, and a urinary fistula resulted; in Bossard's case a calculus was evacuated from the appendix into the bladder and formed the nucleus of what later became a good-sized vesical calculus. In Dalmer's case a fæcal concretion 1.5 cm. long was passed per urethra and later spontaneous healing of the fistula took place.

It must be borne in mind that even deep ulceration and gangrene

do not of necessity lead to immediate perforation of the appendix. In many such cases there results first either a more or less circumscribed or generalized peritonitis, with slight or well-marked intoxication, and the patient dies, or the appendix is removed by operative measures before perforation has ensued. Naturally, however, under such circumstances it is but a question of time when perforation occurs.

In all cases of *typhoid fever* in which morbid alterations occur in the large intestine it is very probable that examination of the appendix would reveal similar changes; and it is likely, also, that in some cases in which the lesions in the large intestine are inconspicuous those in the appendix may be quite marked. Catarrhal alterations are usually well developed, and during the acme of the disease lesions of the lymphoid tissues are prone to be conspicuous. At times these assume such predominance as to give rise to concurrent appendicitis—*typhoid appendicitis*. Rarely, perforation may ensue, and a circumscribed or diffuse peritonitis may result. The sequels of such typhoid ulcerations—such as strictures, etc.—are often of considerable moment in the subsequent production of an attack of appendicitis.

Microscopy.—In ulcerative appendicitis the pathological alterations already detailed in connection with catarrhal and interstitial appendicitis are present, but in much exaggerated degree. There are excessive dilatation and overfilling of the blood-vessels, and marked serous, cellular, and hæmorrhagic infiltration of the coats of the appendix. In the cellular exudate polynuclear leucocytes predominate, and many of these present all gradations of retrograde metamorphosis. The necrosis may result in one of two ways: It may commence by erosion and necrosis of the mucous lining of the organ, and, having involved and destroyed the basement membrane of the latter, may successively invade and destroy the subjacent coats—the submucous, muscular, and subserous tissue—until finally the peritoneal covering may be implicated, perforation ensuing. Less commonly, as detailed in connection with the interstitial form of appendicitis, an abscess situated beneath the unbroken mucous membrane develops. It may be situated in the submucous, the muscular, or the subserous coat, and, depending upon its situation, the subsequent events vary. If it be situated in the submucous

coat, as it increases in size it at first encroaches upon, and finally occludes, the lumen. The epithelial cells of the mucous membrane already participating in the inflammation become deprived of their proper nutritive supply, and as a consequence of this, and also of pressure from the abscess, they degenerate. The abscess finally ruptures into the lumen of the organ and an ulcerated surface remains. This ulceration may then progress until all the coats of the appendix are involved, and perforation, as in the aforementioned case, may eventually ensue. This submucous abscess may develop in the submucous connective tissue by liquefaction necrosis of the inflammatory exudate, or it may result from necrosis of one or more of the lymphoid follicles, as previously stated. If, on the other hand, the interstitial abscess be situated near the peritoneal covering, increasing in size, it may finally perforate externally: that is, into surrounding fibrinous exudate or into the general peritoneal cavity. Under such circumstances, as stated in connection with the macroscopy, there ensues a perforation or rupture of the wall of the appendix without any communication being established between the lumen and the exterior of the organ—no opportunity is afforded for the escape of fæcal matter into the peritoneal cavity. The process of ulceration thus inaugurated may progress, and a communication with the lumen may be subsequently established.

The liquefaction necrosis of the inflammatory exudate and of the appendicular tissues may be quite extensive, having developed rapidly, before there is any evidence of it macroscopically. The cell nuclei no longer stain well; they present chromatolysis, karyorrhexis, or hyperchromatosis; the cell protoplasm, plasmolysis; and, finally, the entire area becomes a mass of granular débris. To this fluid is added and the focus disintegrates entirely and is discharged into the lumen of the appendix, leaving usually an extensive ulcer. At times the process of ulceration is not so rapid; the necrotic tissue maintains some connection with the underlying tissues, and much resembles, upon superficial examination, a false membrane. In all cases of ulcerative appendicitis hæmorrhagic foci are a conspicuous feature. At times these are quite small—microscopical. Again, they are extensive, evident to the unaided eye, and lead to the utmost destruction of the appendix. Entire layers of the several coats are separated by the infiltrating blood, and excessive disturbance

of the topographical relations ensues. At times the blood is found to be in a good state of preservation; again, it is more or less disintegrated, or is represented by blood pigment. Proliferation of the endothelial lining of the blood-vessels is evident in a certain proportion of the cases.

GANGRENOUS APPENDICITIS.

By gangrenous appendicitis is understood an inflammation or infection of the appendix attended by gangrene. This variety of appendicitis has often been referred to as infectious, under the mistaken apprehension that it only, in contradistinction to the other varieties, is due to bacterial infection. The frequency of this variety of appendicitis is indicated by the fact that of 239 cases of acute appendicitis examined, 50 were of the gangrenous variety.

Gangrenous appendicitis, or gangrene of the appendix, may arise in one of several ways. In the first place, as before indicated, any of the previously described varieties of inflammation of the appendix may progress to gangrene. While this eventually may ensue in the course of an inflammation that commenced as a catarrh, be it acute or chronic, it is much more likely to follow the severer forms of inflammation of the organ. In fact, in the event of gangrene we are usually justified in assuming a sudden severe infection in an appendix already the seat of disease. On the other hand, a sudden severe infection, by virulent bacteria or their toxins, of a previously healthy appendix may occur. This infection may be so intense and so overwhelming as to lead to rapid and fatal gangrene, possibly of the entire appendix, before an opportunity has been afforded the tissues to set up counteracting inflammation. Exceptionally, infection may be so intense as to lead to the death of the patient before necrosis has become marked or peritonitis has developed. It is, however, merely a matter of time until the necrosis becomes absolute and peritonitis of a virulent type supervenes. Again, gangrene of the appendix may be caused by sudden and complete withdrawal of the blood supply from the entire organ or from part of it. This may be induced by twists, angulations, etc., or may follow thrombo-phlebitis or thrombo-arteritis consequent upon interstitial or ulcerative appendicitis.

Macroscopy.—If the gangrene occur in the sequence of ulcera-

tive appendicitis, the naked-eye appearances detailed in connection with that variety of appendicitis are considerably exaggerated, both in degree and extent. A quarter, a third, a half, even the entire organ, may assume a dirty greenish-black color; it may become swollen, malodorous, and softened, and may finally become detached from the remainder of the organ or from the cæcum, as the case may be. The gangrenous area presents the appearance of moist gangrene generally. That region from which the gangrenous area has become separated by ulceration is reddened, raw, hæmorrhagic, and the seat of newly formed granulations. The remainder of the appendix, if the entire organ is not gangrenous, presents the appearances detailed in connection with the macroscopy of interstitial and ulcerative appendicitis.

If the gangrene be the result of sudden acute infection, at the end of a short time—from twenty-four to forty-eight hours—the entire organ or a portion of it may be completely deprived of its vitality. The same thing may happen if the blood supply be withdrawn. The portion of the organ affected is distinctly greenish-black in color; it is increased in bulk, much softened, and of a characteristic gangrenous odor. It may still be attached to the remaining portion of the appendix or to the cæcum, and if but a portion be affected, the remainder is in a high state of interstitial inflammation, and is separated from the gangrenous area—at least, after the condition has existed for some time—by a more or less well-developed line of demarcation.

In this variety of appendicitis the pathological alterations and the clinical manifestations may develop with such rapidity as well to merit the designation *fulminating appendicitis*. There may occur within a short time a complete circular amputation of the entire appendix or gangrene of a considerable portion of it—conditions that have been spoken of as *sloughing of the appendix*. In some such cases sufficient time has not elapsed for the formation of peritoneal adhesions, and thus—in contradistinction to the other varieties of appendicitis, in which the organ is commonly surrounded and more or less fixed by adhesions—the appendix may be found to be totally gangrenous, completely detached from the cæcum, and free in the peritoneal cavity. In other cases it may be found separated from the appendix and free in a circumscribed abscess.

The matter exuding from the opened lumen of such gangrenous appendices is usually pus. At times appendicular calculi may be found, either in the lumen, projecting from it, or in the surrounding purulent matter or exudate. In 49 of the cases of gangrenous appendicitis examined they were found in 5 (10.2 per cent.). Doubtless others, however, at the time of operation had already escaped from the appendix and were not detected in the surrounding exudate or pus. As already indicated, the gangrene may affect the whole or a portion of the appendix. There may occur a circular amputation anywhere, or but a portion of the circumference may be involved.

After spontaneous amputation the appendix occasionally escapes necrosis, being nourished either by the appendiceal artery or by newly formed vessels from the surrounding exudate. The mucous membrane may then be the source of a persistent mucous fistula, which can be healed only by the complete removal of the remnants of the appendix.

Most unusual and remarkable conditions are sometimes encountered. An instructive instance is the case in which, at a secondary operation for the cure of two fistulous tracts persisting after a primary operation, the appendix was found to consist of the tip connected with the proximal half by a band of the meso-appendix. The opening in the appendix was in communication with the two fistulous tracts. Jopson reports a somewhat similar case, a fistula from which there was a profuse mucous discharge.

Microscopy.—Those portions of the appendix actually the seat of gangrene naturally present no structure that can be identified with certainty. Other portions of the organ present all gradations from moderate interstitial inflammation and ulceration to actual gangrene. If gangrene follow catarrhal or interstitial inflammation with ulceration, in certain regions—unless the entire appendix is already gangrenous—there is more or less extensive destruction of the surface epithelium, and to some extent also of the protecting basement membrane. It is not improper to assume that this latter structure is of considerable importance in protecting against infection. The exposed and unprotected mucosa and submucosa afford a congenial soil whence infection of the entire wall is a matter readily accomplished. In addition, there are noticeable high grades of interstitial

inflammation, with abundant round-cell infiltration, suppurative foci, larger and smaller areas of hæmorrhage, and more or less extensive necrosis. The individual cells present plasmolysis, chromatolysis, karyorrhexis, and hyperchromatosis. Adipose tissue becomes converted into free fat and fatty acids, muscle fibres become indistinct and dissolved, and the entire tissue breaks down into a granular and semi-fluid débris. Hæmorrhages ensue, either from erosion of the vessels or, not uncommonly, from the result of the direct action of the bacteria and their toxins on the vessel walls. If a line of demarcation have formed, it presents, on the one hand, all the evidences of liquefaction necrosis until the sphacelus is cast off; and, on the other, the ordinary evidences of inflammatory reaction—commonly, however, with but slight manifestations of regeneration. If the gangrene be the consequence of sudden severe infection with very virulent bacteria, or of the sudden and complete withdrawal of the blood supply consequent upon twists, flexures, thrombo-phlebitis, or thrombo-arteritis, the entire appendix or a large portion of it presents evidences of very diffuse gangrene without manifestations of reactive inflammation. Under such circumstances the gangrene affects a large portion of the appendix uniformly, and does not appear to have been the result of the progression of the other varieties of inflammation of the appendix. The deeper layers of the organ are quite as much involved as the superficial.

CHRONIC APPENDICITIS.

In some presumably diseased appendices, particularly in some of those removed from patients presenting clinical evidence of chronic appendicitis, histological alterations are not especially conspicuous. In a few instances they are not more marked than are those sometimes detected in appendices removed at necropsy from subjects who during life presented no definite indications of appendicitis. In some cases the only tangible and unmistakable evidences of disease are peritoneal adhesions binding the appendix to various tissues or organs. Thus, the query naturally arises: When is the appendix to be regarded as pathological? It need hardly be stated that in a number of cases, especially of chronic appendicitis, a microscopical examination of the organ must be

made before a trustworthy opinion as to its condition can be formulated.

In many instances disease of the appendix has been detected postmortem in subjects who during life manifested no noteworthy clinical evidences of such deviations from the normal. Thus, Kraussold states that one-third of all adult bodies reveal diseased appendices; Toft found the appendix diseased in 100 out of 300 subjects upon whom he performed necropsies; Hawkins detected evidences of past or present disease of the appendix in 16 out of 100 subjects. Personally, I believe that careful macroscopical and microscopical investigation will reveal indications of disease in at least one-third of presumably normal appendices removed from adults. Kelynack, on the other hand, believes that the statistics of Ransohoff—who found diseased appendices in 8 out of 60 subjects—represent more nearly the usual proportion. In many of these cases there can hardly be any question that the patients did not present any evidences of serious disease; on the other hand, the appendix cannot be regarded as normal. It is not likely that the lesions began acutely; rather, they commenced chronically, insidiously, and it is but fair to assume that, had the patients lived long enough, or had an appropriate infection occurred, they would inevitably have suffered the evil consequences of these morbid changes. In other cases the patients complain of various indefinite abdominal symptoms that are referred to disease of one or another of the abdominal organs. At times, however, the affection is recognized as chronic appendicitis, and the good effects attending operation for the excision of the offending organ sufficiently attest that even minor pathological alterations of the appendix may give rise to more or less aggravated and persistent clinical symptoms. Many of these cases doubtless belong to the class that Ewald has incorrectly designated *appendicitis larvata*. Rather should they be termed cases of appendicitis difficult of diagnosis. They should not be confounded with those cases that Nothnagel, among others, has described under the caption of hysterical mimicry of appendicitis. The hysterical nature of a case of suspected appendicitis should not be especially difficult of recognition.

Many patients not in the least hysterical suffer severely and repeatedly from more or less aggravated attacks of recurring appen-

ditis; and still, in some instances, the appendix, when excised, presents but minor pathological alterations. Doubtless in some cases the inflammatory phenomena subside with greater or less rapidity, and in the absence of extensive histological evidence of disease, it is not always warrantable to assert that the removal of a given appendix was not justified. It must further be admitted, in view of the difficulty sometimes experienced in distinguishing between the results of inflammatory disease and certain developmental anomalies and retrograde alterations, that, in certain isolated cases, the clinical history is of decisive importance. All of the foregoing, however, are exceptional cases. Ordinarily, there is no difficulty whatever in recognizing the lesions of chronic appendicitis.

CHRONIC CATARRHAL APPENDICITIS.

By chronic catarrhal appendicitis is understood a chronic inflammation of the appendix in which the pathological alterations are wholly or almost wholly confined to the mucous membrane, the other coats presenting little or no deviation from the normal. This is a very uncommon variety of appendicitis, for the reason that the causes inducing the inflammation, from their very nature, entail consequences that render the limitation of the pathological alterations to the mucous membrane extremely unlikely. There can, however, be no question that cases of catarrhal appendicitis do occur. They are cases that clinically pursue a mild course, being, possibly, now and then subject to minor acute exacerbations. The clinical history of some cases of appendicitis indicates the existence of appendicular disease for a considerable period of time, and yet examination of the excised appendix reveals only catarrhal lesions. The occurrence of such cases has been indicated by various observers from time to time and 1.7 per cent. of the chronic cases that were examined were of this variety.

Macroscopy.—Macroscopical examination shows the appendix to be a little thicker, stiffer, and firmer than normal. On incising it, the mucous membrane is found to be of a grayish color and somewhat thickened. The crypts of Lieberkühn are moderately distended and the mucous membrane is covered with a layer of rather thick mucus. This mucus may also fill more or less completely the

lumen of the organ. There is, however, commonly associated with the mucus, some faecal matter, or, rarely, a calculus. The calibre of the lumen may vary somewhat at different levels, usually as a result of previous attacks of inflammation. If to such chronic catarrhal inflammation there be added an acute exacerbation, the evidences of the latter, as already narrated, will be manifest.

Microscopy.—The crypts of Lieberkühn are more or less distended with mucus, and some mucous droplets are also seen in the epithelial cells lining these crypts and the lumen of the organ. Naturally, these are not so conspicuous as in the acute variety. In the mucosa there are a few round cells and spindle cells and connective-tissue hyperplasia. At times the vessel walls of this region are thickened, and there may be some foci of blood pigment.

It is extremely improbable that in chronic inflammation of the appendix the lesions will remain indefinitely localized to the mucous membrane. They tend to become diffuse, constituting chronic interstitial appendicitis.

CHRONIC INTERSTITIAL APPENDICITIS.

By chronic interstitial appendicitis is understood a chronic inflammation of the appendix in which all the coats of the organ are involved. In certain instances one or more coats exhibit pathological alterations out of proportion to those of others, but usually deviations from the normal, more or less conspicuous, may be detected in all. This is the common variety of chronic appendicitis. In fact, excepting those relatively rare cases in which the lesions are strictly confined to the mucous membrane, and others due to certain specific micro-organisms—such as the tubercle bacillus, etc.—all cases of chronic appendicitis are of the interstitial variety. These are the cases clinically spoken of as chronic appendicitis, relapsing appendicitis, recurring appendicitis, etc. Clinically and pathologically, it suffices to designate them chronic appendicitis. Of course, an acute exacerbation may develop at any time. Of the 305 cases of chronic appendicitis examined, 299 were of the interstitial variety, 6 of these, however, being of the subclass designated obliterating appendicitis.

Macroscopy.—The naked eye appearances vary considerably

in different cases. The simplest form is that in which the condition follows the subsidence of a minor grade of acute inflammation, or in which the process commences as a chronic inflammation, the lesions not being limited to the mucous membrane. The organ is thicker, stiffer, and firmer than normal, and is non-collapsible. The appearances of its mucous membrane and contents do not differ especially from those described in connection with chronic catarrhal appendicitis. At times the lumen is much reduced, varies in calibre in different regions, and contains one or more calculi. Of 252 of the chronic cases examined, calculi were noted in 39 (15.5 per cent.). Whether the lesions are confined to the mucous membrane, or are distributed throughout all the coats, is at times determinable only upon microscopical examination. Again, however, the walls are excessively thick, and justify the inference that the lesions are widespread. In a great number of cases I have found the external diameter of the appendix to be from 12 to 14 mm. and more, and the lumen less than 2 mm.

Reference has been made to the frequency of erosions and ulceration of the appendix in cases of acute inflammation, and it was stated that if the inflammation were not very intense, the acute manifestations might subside, the process becoming chronic. Under such circumstances certain important results ensue. That portion of the wall of the appendix which is the seat of erosion or ulceration is replaced by newly formed connective tissue, which like all newly formed connective tissue, tends to contract and to form cicatricial tissue. As a consequence the lumen becomes contracted. If there have been several points of ulceration, there will also be several points of stenosis of the lumen. Depending upon the situation, size, and shape of these cicatrices, there results either a transverse narrowing of the lumen, or, particularly if the cicatrix be longitudinal rather than annular, there will ensue a shortening of the organ along one side—a curling-up of the appendix, or an angulation, flexure, twist, etc. If there be several cicatrices, the utmost distortion of the appendix may be produced, and the lumen of the organ may be represented by several cavities separated from one another by areas of constriction. It is in those portions of the lumen limited by stenosis that appendicular calculi are particularly liable to be encountered. Not infrequently they give

rise to chronic erosion and ulceration. It must be borne in mind that such ulceration may also be due to causes other than calculi, as, for instance, tuberculosis, bacterial toxins, acute exacerbations of inflammation, etc.

On the other hand, there may be complete obliteration of the lumen of the appendix at one or more points along its length. It is readily conceivable that in the event of annular ulceration, granulating surfaces being everywhere apposed to granulating surfaces, these adhere, and, as the processes of regeneration and organization go on, become permanently united by means of newly formed connective tissue. Such obliteration of the lumen may be circumscribed or generalized. In the latter case obliterating appendicitis results; in the former, merely a local obliteration. The latter may be situated anywhere, and not uncommonly gives rise to a condition known as *cystic dilatation*, *retention cyst*, *hydrops*, or *mucocoele* (Féré) *of the appendix*. This is a condition in which that portion of the appendix distal to the obliteration becomes distended and filled with fluid. It was first recognized by Virchow, who spoke of it as colloid degeneration of the appendix. Depending upon the site of the obliteration, a portion of the appendix or the entire organ may be affected. Commonly, the dilatation is confined to the distal half of the organ, but the entire organ is relatively often involved. Rarely, a central portion may be implicated, the tip and proximal portions being free. Under such circumstances, however, the tip is much more likely to be entirely obliterated.

These cystic dilatations vary much in size. At times they are not much larger than a walnut, but instances of excessive size have been reported. Virchow stated that they might reach the size of a large fist. One removed by Deaver from a woman, aged twenty-five years, who had had two attacks of appendicitis, was the size of a small orange, and was adherent both to the neighboring coils of small intestine and to the right broad ligament. The lumen of the appendix was entirely occluded one-quarter of an inch from its cæcal end.

In shape they may be ovoid, cylindroid, round, or irregular. The character of the contained fluid also varies. It may be clear or slightly turbid, tenacious, gelatinous, or sometimes more limpid and watery. Leube long ago drew attention to the fact that at

first the contained fluid consists of tenacious mucus, and that it later assumes the characteristics of a watery serum. This ensues because the wall of the appendix, as it becomes distended, usually also becomes thinned, its inner surface growing smooth and the distribution of its vessels being more superficial than normal. This results, on the one hand, in facilitating the escape of the watery portion of the blood, and, on the other, in reducing to a minimum the formation of mucus.

Some very unusual conditions have been reported. Thus, Coats, Weir, and Kelynack have observed cases in which the contents were gelatinous in character. In Kelynack's case "the appendix was greatly distended, and presented two very distinct diverticular processes, which were directed beneath the folds of the mesentery of the appendix. The diverticula were connected with the dilated cavity of the appendix through well-defined circular openings." Stengel found in about 2000 autopsies one case of true mucoid cyst of the appendix. He describes the condition and shows it to differ entirely from simple mucocele of the appendix, and considers it as being possibly allied to colloid carcinoma. Hawkins states that there is a specimen in St. Thomas's Hospital Museum that shows five or six diverticula on the surface of the cyst. Werth, Fraenkel and Neugebauer have described cases of multiple "pseudocyst" formation, in which multiple gelatinous globules have studded the appendix and even the surrounding visceral serosa. Hawkins, Bland-Sutton, and Page report cases in which the contents consisted of purulent matter; but these were probably ordinary empyemas of the appendix. Fenwick reports a case in which the appendix was distended by a "milky fluid." Guttman reports a case in which the dilatation was 14 cm. in length and 21 cm. in its greatest circumference.

Not all cases, however, are due to obliteration of a portion of the lumen of the appendix; sufficient obstruction may be produced by a very acute angulation. An instructive case of this sort has been reported by Treves and Swallow. A tumor two inches in length and one inch in diameter was made up of the appendix acutely bent upon itself and distended with mucus. The angulation was maintained by old peritoneal adhesions. When this was relieved, the contents escaped of their own accord.

The development of this condition of cystic dilatation of the appendix depends upon several factors. The obstruction of the lumen must be complete, or almost so; the obstruction or obliteration must have obtained at a time when the affected portion of the organ contained no pathogenic micro-organisms; the mucous membrane of the affected portion must be intact, or at least capable of functioning; and the secretion by the mucous membrane must be more rapid than the absorption from the portion of the appendix involved. If the obstruction be not complete, the secretion is likely to be forced through even a narrow opening with sufficient rapidity to prevent a large accumulation, and, on the other hand, infection is likely to occur through the patulous lumen, converting a cystic dilatation into an empyema. If there are already virulent bacteria in the affected portion of the appendix, an empyema, of course, rather than a cystic dilatation, will develop in the first place. If the mucous membrane is incapable of functioning, there can be no accumulation of fluid, and the same is also true if absorption be more rapid than secretion.

The condition is readily recognized as cystic dilatation of the appendix. The mucous membrane is usually smooth, and is generally in a high state of atrophy as a consequence of mechanical pressure. There is also marked atrophy of the lymphoid follicles. If the distention be but moderate, it is not uncommon to find the wall much thickened, as a result of compensatory hypertrophy of the muscular coats, and also of some connective-tissue hyperplasia. Both these conditions, as evidences of chronic inflammation, as is mentioned elsewhere, may have developed prior to the hydrops. If with the occurrence of the distention the wall does not increase still more in thickness, it is likely to become much attenuated under the influence of the progressive accumulation of the fluid.

Microscopy.—The microscopical appearance of the extirpated appendix in cases of chronic appendicitis varies considerably in different instances. In some cases in which the clinical manifestations have extended over a period of some years the microscopical evidences of disease are very slight. In these cases, however, the indications of disease are self-evident from the macroscopical appearances, the distortions of the organ, and the chronic peritoneal adhesions. Even in these cases, however, careful microscopical

examination will usually detect some of the catarrhal alterations already detailed in connection with chronic catarrhal appendicitis and some hyperplasia of the submucous or muscular coats or of both. In addition, more or less round-cell infiltration will commonly be noticeable. In other cases the hyperplasia of the submucous and muscular coats is excessive, and there is considerable round-cell infiltration, which is usually scattered in small amounts throughout the various coats. If the lesions of the mucous membrane, already referred to, are not present, there is commonly more or less atrophy of this structure, and in some instances it is replaced by cicatricial connective tissue—the lumen, under such circumstances, being very narrow. In most cases of chronic appendicitis a hyaline degeneration of the submucous and muscular coats is a rather conspicuous feature. This varies in extent in different cases, at times being minimal, at others quite diffuse. If the appendix be examined while the process of cicatrization of an ulceration is in progress, remnants of the mucous membrane may still be detected. This, however, is not usual. On the contrary, what remains of the mucous membrane and submucosa is the seat of extensive round-cell infiltration, which is present also, to a greater or less extent, in the muscular coats. As a consequence of this round-cell infiltration, and of some hyperplasia of the submucous and muscular coats, the wall of the appendix is thickened and non-collapsible, and peristalsis is inhibited. Conditions are favorable, therefore, for the approximation of the opposed granulating surfaces—the free edges of the lumen—and for the formation of adhesions. In many cases delicate strands of embryonic connective tissue may be seen bridging the narrow slit—remains of the lumen—and uniting the opposed surfaces. In the early stages of this process, however, these strands are so delicate that they are frequently torn in the manipulations necessary in preparing the sections, and hence may be overlooked. Newly formed blood-vessels are frequent, and about these there spring up new granulations, which tend to cicatrization and to the formation of fibrous connective tissue. Obliteration of the lumen at some point may now be complete. Cicatrization continues, and the diameter of the appendix becomes, in consequence, gradually lessened. The blood-vessel walls are often thickened, and at times there is inter-

stitial hyperplasia of the nerves, especially of those of the meso-appendix. There may also be some proliferation of the endothelium of the blood-vessels.

OBLITERATING APPENDICITIS.

By obliterative or obliterating appendicitis is understood a variety of interstitial inflammation of the appendix attended by or leading to obliteration of its lumen. We have found 2 per cent. of the cases of chronic interstitial appendicitis to be of this subvariety.

Macroscopy.—Upon naked eye examination such appendices, as a rule, do not differ materially from those described under the heading Chronic Interstitial Appendicitis. In some instances, however, the region of the obliteration of the lumen is made evident by a marked thinning of the appendix, which may be reduced to one-half or less of its original size. Exceptionally, it may be reduced to a mere filament; and if but a portion be so affected, this presents a marked contrast to the remaining portion, which may be normal in thickness, or even somewhat increased, as a consequence of hyperplasia of the muscular coats. Upon endeavoring to incise the organ—that is, to open its lumen lengthwise—the obstruction or obliteration of the lumen is encountered. This may be situated anywhere along the course of the appendix, and, depending upon the stage of the process, there may be friable bands of adhesions or an impervious band of dense cicatricial connective tissue. Indeed, the whole appendix may be converted into such an impervious band of connective tissue by obliteration of the entire lumen. Under such circumstances, of course, subsequent attacks of appendicitis are rendered impossible: that is, a so-called natural cure has resulted. Such an event is of no great rarity. Usually, the obliteration is limited to a portion of the organ, which may be the tip, the distal third, a half, or more. At times, as already indicated, the obliteration may affect a portion of the appendix at a distance from the tip, and the latter, if its mucous membrane be preserved and functional, may subsequently become the seat of cystic dilatation. Appendices the seat of obliteration of the lumen are commonly embedded in a dense mass of fibrous

adhesions, which, by contracting, tend to hasten the process of obliteration. Even if complete obliteration occurs, these adhesions, which remain, sometimes give rise to disastrous intestinal and other complications.

Senn, who has directed particular attention to the obliterating variety of appendicitis, speaks of varying degrees of contraction of the lumen of the appendix that he has encountered, and that differ in extent from slight stenosis to complete obliteration; and these cases he includes in his category of obliterative or obliterating appendicitis. It seems to me, however, that this is an incorrect interpretation of the pathological conditions, and that it is much wiser to limit the designation obliterative appendicitis to those cases in which an actual obliteration of the lumen occurs, and to exclude those cases developing merely a constriction—a stenosis of the lumen. These are essentially different pathologically. In the latter the lumen is preserved, though it tends to become progressively smaller, and is always less than normal; it may be lined in part by epithelium, or in great part by cicatricial connective tissue, but there is still some opening through the stricture, just as there is through a stricture of the urethra, which is hardly spoken of as an obliterative urethritis. In the case of true obliterative appendicitis, however, the opposed surfaces of the lumen have become firmly united to each other, and the obliterating band is absolutely impervious. Were the designation obliterative appendicitis employed in all cases in which the constriction of the lumen becomes marked, many of the cases that I have included in the category of simple chronic interstitial appendicitis would necessarily be classed as obliterative—a classification impossible of justification.

Microscopy.—The microscopical appearances of the appendices in cases of obliterative appendicitis do not differ from those described in connection with chronic interstitial appendicitis; they are merely more extensive. In extreme cases microscopical examination may reveal nothing but dense cicatricial connective tissue and a few muscle fibres, especially in the impervious bands mentioned.

There are several particular forms of chronic disease of the appendix that may be attended by ulceration and that demand

special consideration. Of these, the most important are tuberculosis and actinómycosis.

Tuberculosis of the appendix may be primary or secondary, miliary or caseous. Primary tuberculosis of the appendix must be accounted among the greatest of rarities, and it may be doubted whether any well-authenticated case of primary tuberculosis of the appendix has yet been recorded. Even in the event of detecting tuberculosis of the appendix alone, particularly at operation, it is hardly possible to assert with certainty that tuberculosis does not exist elsewhere in the body; that the condition is primary in the appendix. Of the occurrence of tuberculosis of the appendix in association with, or secondary to, tuberculous lesions elsewhere in the body a great number of instances have been observed. There are, however, no trustworthy statistics of sufficient magnitude upon which to base an opinion as to the frequency of their occurrence. Fenwick and Dodwell, who reported the records of the necropsies performed upon 2000 subjects dead of tuberculosis in the Brompton Hospital for Consumption, found that the intestine was the seat of ulceration in 500 (56.6 per cent.) out of 883 cases. In 85 per cent. of these cases the ileo-cæcal region was involved; in 9.6 per cent. it was the only portion of the intestine that showed evidence of disease. From this region the frequency of implication diminished in both directions. Thus, the jejunum was involved in 28 per cent. of the cases; the duodenum, in 3.4 per cent.; the ascending colon in 51.4 per cent.; the transverse colon, in 30.6 per cent.; the descending colon, in 21 per cent.; the sigmoid flexure, in 13.5 per cent.; and the rectum, in 14.1 per cent. It was quite exceptional to find the appendix uninvolved when there was disease of the ileo-cæcal region; in 17 of the cases the appendix was the only portion of the intestinal tract that presented ulceration. Whether or not this ulceration was tuberculous was not definitely determined.

Upon macroscopical examination tuberculosis of the appendix is likely to elude observation in many cases. The lesions may not differ materially from those of simple catarrhal inflammation or ulceration of the appendix. On the other hand, the entire mucous membrane may have become converted into a discolored caseous mass, with more or less extensive ulceration. At times the nature of the affection may be recognized by the detection of

minute grayish tubercles in the floor of the ulcer, or similar tubercles may reveal themselves beneath the peritoneal coat of the organ. If there be extensive tuberculous disease elsewhere in the body, of course, the tuberculous character of the lesions of the appendix is more likely to be recognized. If the disease be of the miliary variety, it should not escape detection; it is usually associated with similar disease of other intra-abdominal organs or tissues, particularly the peritoneum. Tuberculosis of the appendix does not manifest any very marked tendency to perforation, though such eventuality may occur. In almost all cases there is associated a more or less circumscribed tuberculosis of the peritoneum. The lesions are eminently chronic, and tend to the formation of fistulas.

Upon microscopical examination the well-known lesions of tuberculosis are detected. There are more or less extensive formation of epithelioid cells, giant cells, and round-cell infiltration, with a varying amount of caseation and partial or complete degeneration of the cellular exudate. The lesions are prone to involve the lymphoid follicles and to spread along the submucous coat, possibly involving other tissues; but histologically they do not differ from similar lesions in other portions of the body. With appropriate staining procedures tubercle bacilli may be detected.

Actinomycosis of the appendix is a rare condition due to the pathogenetic activity of *Streptothrix actinomyces*, or ray fungus. Actinomyces in man is itself a rather rare condition, and up to 1899 Ruhräh was able to collect from the literature but 70 cases reported in this country. Of these, the appendix was affected in 5. Hinglais, who has studied the appendico-cæcal form, found it in 60 out of 100 cases of the abdominal form. Grill, in reporting four personal observations of the abdominal form of the disease, was able to find 107 other cases in the literature. In 40 of the latter the portal of entry of the actinomyces was definitely made out, and was as follows: The appendico-cæcal region in 19; the colon in 8; the rectum in 7; and other portions of the intestinal tract (jejunum, duodenum, etc.) in 6. In 26 of the cases the process was perityphlitic and paratyphlitic, but no portal of entry could be definitely located; in 7, the process was peri-rectal; and in 36, the portal of entry was entirely indeterminate. Since the last edition of this book but few additional cases of actinomycosis of the appendix have been reported.

To the total of 39 cases there tabulated may be added one case by Rowntree, seven by Waring, and two by Murphy, making a total of 49 cases up to the present time.

Actinomycosis of the appendix may be the result of direct infection—through the intestinal tract; of indirect infection, or extension from the thoracic cavity—through the diaphragm, behind the peritoneum, or through the abdominal muscles; or it may be the consequence of metastasis. According to Hinglais, the affection may be divided into four stages; (1) The period of visceral symptoms, which may last from a few days to several months; (2) the period of tumor, which varies much in duration, and during which frequent remissions may occur; (3) the period of fistula, during which the disease may extend to other tissues, such as the lumbar region, the psoas muscle, the hip-joint, the space of Retzius, etc., and during which extensive abscess formation, with fistula, which is likely to be multiple, may develop; (4) the period of reparation, during which the affection may heal spontaneously or as a consequence of surgical procedures. On the other hand, the disease may persist indefinitely and may finally terminate fatally.

It is agreed by many writers that it is most likely that the affection in these cases is primary in the appendix; that the fungus is carried to the appendix by some grain or fragment of corn or barley; and that this lodges in the appendix, wherein the actinomyces proliferates. Waring, on the other hand, holds that the appendix is not always the primary seat of the disease, but that actinomycosis like tuberculosis is more frequently primary in the cæcum. Czerny and Haeddeus, from a careful study of their cases, conclude that there first occurs an infection of the appendicular mucous membrane, which becomes necrotic and gives rise to the formation of an ulcer. This permits of ready access of the actinomyces to the submucosa, wherein it further proliferates, and, meeting with slight resistance, extends in various directions. In one of their cases the mucous membrane did not appear ulcerated, and this fact is explained by supposing that, after the formation of the ulceration and the infection of the submucosa, reparation of the mucosa occurred, and that the necrotic mucous membrane was replaced by cicatricial connective tissues. These suppositions are confirmed by the absence of Lieberkühn's glands in the mucous membrane. Infection having occurred,

suppuration, with the formation of fistulas, may supervene, or there may result the development of thick, indurative connective tissue. This differs from ordinary cicatricial connective tissue in that it contains small foci of pus, which may be absorbed if the fungus be absent. If the fungus be present, on the other hand, there may ensue further extension of the disease. In the peri-appendicular pus the characteristic grayish nodules may be detected. Upon microscopical examination these are found to be composed in whole or in part of *Streptothrix actinomyces*.

It has been pointed out by Barth, Partsch, and other observers that in those cases in which there occurs symbiosis, with the ordinary pyogenic cocci, the actinomycotic nature of the affection is likely to be non-apparent. It is only later, when, as a consequence of extension or metastasis, the disease develops in another portion of the body, that the true nature of the original infection is recognized. Probably because of this, and because some unsuspected cases have been cured at the primary seat of the disease, actinomycosis of the appendix seems more rare than it really is.

Tumors of the Appendix may be primary or secondary, benign or malignant. Primary tumors, both clinically and histologically benign, are very uncommon. Lafforgue, in 1893, reported 6 cases in his series of 17 tumors of the appendix including one lipoma, one myoma, two lymph-adenoma, and two hydatid cysts. From time to time since then an occasional report is made of such benign growths arising in the appendix. Kelly, Schrupf, Pressly and Oberndorfer have reported cases of appendiceal polyps. Kelly, Monnier and Aboulker have observed plain myomata, while the former has described a fibromyoma that was calcified.

Personally, I have encountered two cases of fibromyoma of the appendix. One was from a patient the subject also of fibromyomas of the uterus, and both organs were removed at the same operation.¹ The appendix presented two fibroid growths, each of which was spheroid in shape and about five millimetres in diameter. One was situated at the mid-point of the appendix, opposite the attachment of the mesentery; the other toward the tip of the organ, within the mesenteric attachment. They projected somewhat from the surface

¹ This case has been reported by Dr. Deaver in the Transactions of the Academy of Surgery of Philadelphia, vol. 1, 1899, p. 23.

of the appendix, and each was well circumscribed, surrounded by a rather dense capsule, and was firm to the touch. On section they were whitish and glistening, and revealed a fibrillar structure. One was much harder than the other—being of almost stony hardness—and cut with a grating sensation. The wall of the appendix elsewhere was much thickened; the lumen much constricted. The mucous membrane appeared smooth and atrophic. On microscopical examination the lesions of moderate interstitial appendicitis (as already detailed), with considerable thickening of the walls of the blood-vessels were detected. The tumors consisted of bundles of dense fibrous connective tissue that coursed in various directions and intertwined among themselves, and interspersed between which there was a small amount of unstriped muscle fibres. The connective tissue contained relatively few nuclei and an abundance of intercellular substance. The blood supply was moderately good, but the walls of the blood-vessels were thickened. The growth opposite the attachment of the mesentery contained a considerable amount of calcareous infiltration. The second specimen was much like the first. There was, however, but a single nodule, which contained no calcareous infiltration. In other respects the resemblance was marked.

Carcinomata.—At the time of the first editing of this work primary malignant tumors of the appendix were very rare. As mentioned above, Lafforgue in 1893 found but nine cases in the literature to that date. At the second editing Dr. A. O. J. Kelly was able to collect but twenty authentic cases, but stimulated by these interesting observations more systematic microscopic examination of appendices removed at operation has been followed by a steady increase in finding of malignant new growths in the appendix, so that in 1905 at the third editing of this work Dr. Kelly was able to report on forty-five cases of malignant appendiceal neoplasms.

Since 1905 there has been a continued increase in the number of cases reported, and in 1908 McWilliams brought the total up to 105 cases, and in the same year Harte collected 120 cases, and though a thorough compilation since that date is not at hand but a cursory review of the literature is needed to assure one that the number is still rapidly increasing, and it can therefore be readily seen that this condition ceases to be a rarity.

The ability to collect as large a number as is possible at present naturally leads to analysis and study of this important problem of to-day and we are now able to discuss the question from a sufficient series of careful observations to draw some definite conclusions as to their occurrence and characteristics of growth, to point out their peculiar benignancy, to describe their typical histological malignancy and possibly to throw some light on their origin. It is gratifying at this time to be able to remark on the active work along these lines that has been borne by American investigators and it is from them that the early systematic microscopic examinations of appendices removed at operation were rewarded by the rather frequent finding of neoplastic growths, and the literature upon the subject is mostly to be found in the English language.

The **age** of the patients presenting carcinoma of the appendix is one of the most interesting features, for the usual rule of malignancy is broken and we find the time of occurrence far below the "cancer age" in an overwhelming majority of cases. No less than 65 (54 per cent.) of the 120 cases reported by Harte occurred before the age of thirty years, while 60 per cent. of the 105 cases collected by McWilliams were discovered before that age, and again, in Harte's series 104 of the 120 cases were found before the end of the fifth decade, while Oberndorfer says that 70 per cent. occur before the end of the fourth decade. The average age of occurrence has been put by MacCarty and McGrath as thirty years. Vassmer put it at 35.3 years, and Milner at twenty seven and one-half years. The former reports a case occurring in a child of five years, Oberndorfer discovered a malignant appendiceal growth in a child of seven years, while Day and Rhea report a case at nine years of age and there are numerous other observations reporting cases before the age of puberty. That practically all these cases were diagnosed and operated upon for appendicitis is of course recognized and the association of inflammation with the presence of carcinoma (later to be discussed) is also marked. So that it is to be expected that during the years of life when operations for inflammatory conditions of this organ are most frequent that the greater number of cases of early carcinoma originating in the appendix should be found, and the condition simply disclosed by operation. One means of explaining this early occurrence is in the type of cell forming the

carcinoma. Warthin is of the opinion that the vast majority of these growths are of the spheroidal or basal cell type of carcinoma and in his statistics shows that the average age in the spheroidal cell carcinoma was but twenty-four years, while in the columnar cell type it was about fifty years of age which more nearly corresponds to the age at which primary carcinoma of the intestine (the majority here being of the columnar cell type) occurs. Moreover, this prevailing variety of spheroidal cell carcinoma is less prone to give malignant metastasis, a feature of marked significance in these appendiceal tumors.

The **association of appendicitis** with these neoplastic growths and the frequent, simultaneous occurrence of both conditions in this organ has been recognized and dwelt upon by all writers and the question naturally arises, which of the two conditions is the primary one. As we now study the cases it appears that nearly all have presented symptoms sufficiently alarming to warrant operation under the diagnosis of chronic appendicitis, and even in the cases where acute inflammation has been found in association with carcinoma the probability is that this acute condition has been grafted on an old case of chronic inflammation of the appendix. But if ultimately appendicitis is proven the *primum movens* in the development of appendiceal carcinoma, we cannot at present deny the possibility that the reverse may be true.

The histological picture of carcinoma of the appendix when it arises, as it frequently does, in connection with obliterative appendicitis lends attractive support to Ribbert's theory of the origin of malignant growths; that tumors arise from a partial or complete separation of cells, or groups of cells, from their organic continuity, in other words from a mechanical isolation which as we know finds its chief cause for their detachment in chronic connective tissue inflammation. We cannot, however, eliminate the possibility of malignant change in the normally situated epithelium under the conditions of chronic irritation that exists so frequently in chronic appendicitis.

Maschowitz states that 66 per cent. of the cases studied by him were preceded by symptoms of acute inflammation of the appendix and in McWilliam's statistics 63 per cent. had had associated inflammatory changes.

As it has been shown to be the rule to find chronic inflammatory changes associated with the new growths, so also a large number of these cases show definite *obstruction of the lumen* and in many cases complete obliteration of the lumen had taken place proximal to the neoplasm. This also must be taken as a possible ætiological factor and has so been dwelt upon by many authors. MacCarty and McGrath find carcinoma present in 1.9 per cent. (or once in every fifty-three cases), of partially or totally obliterated appendices removed at operation.

The **location** of the growth is apparently in close relationship to the aforementioned obstruction of the lumen and the predilection of the neoplasm to occur in the distal portions of the organ is quite marked. MacCarty and McGrath report 90 per cent. as being "in the tip" of the organ, while 76 per cent. of McWilliams' cases are stated to have occurred distal to the middle of the appendix. The prevalence of the occurrence of malignant changes in the distal portion has also a pathological significance, though probably closely allied to the associated inflammatory changes, yet that this occurrence of the neoplasm in the distal portion, whatever it may be due to, has some important bearing on the late formation of metastasis must also be considered.

A unique feature is the small *size* of the growth even in cases found at autopsy in elderly people. Rarely is the tumor described as greater than a walnut in extent and this of course is in just relationship to the known benignancy later to be discussed. Of course we must remember that in dealing with as small an organ as the appendix that large growths may have occurred, and as such have given rise to metastasis, the primary growth itself infiltrating the cæcal wall, and have as a result been classified as tumors of the cæcum and their appendiceal origin has been completely hidden, but nevertheless the rule has been to find only a small nodule which on microscopic examination reveals the picture of a malignant epithelial neoplasm.

There is a slight predominance of occurrence in the female *sex*, and though the anatomical relations are identical in the male and female with the exception of an occasional appendiculo-ovarian ligament in the latter, this increased occurrence is sufficiently marked to be worthy of comment. Fifty-seven per cent. of McWilliams'

105 cases occurred in women and 69.4 per cent. in Harte's series were of the female sex.

The incidence of carcinoma of the appendix will largely depend upon the thorough microscopic study of all appendices removed, for, as has been said above, practically all of the cases have been operated upon under the diagnosis of appendicitis and only subsequent close investigation, aided by microscopic study, has demonstrated the presence of a neoplastic growth. MacCarty and McGrath found the incidence to be 0.44 per cent. and in their series of twenty-two cases in 5000 appendectomies this meant once in every 227 diseased appendices. McWilliams has found it twenty-six times in 6505 appendectomies, that is 0.4 per cent., or once in every 250 cases. Baldauf claims that 1 per cent. of all inflamed appendices will be found to show malignant changes, while Harte says it is present in one-third of 1 to 1 per cent. of the cases. In the previous edition of this treatise the percentage was placed at 0.2 per cent. and to date (Sept. 1, 1912) in the service of Dr. Deaver at the German Hospital, Philadelphia, 6327 appendices have been examined microscopically and sixteen instances of malignant neoplasm have been found giving the percentage as 0.25 per cent., or once in every 395 cases.

The **clinical benignancy** is a striking feature of carcinoma of the appendix. Milner (1909) goes so far as to say that a true clinically outspoken carcinoma of the appendix has not been described. That the majority of these cases are completely cured by appendectomy alone and that recurrence is a rare condition cannot be denied. It is true that, possibly excepting the cases of Voeckler and of Lejars, recurrence has been most rare and the histological picture shows no trace of a malign character, such a destruction of tissue, numerous mitotic figures and widespread invasive power while the cells themselves are usually small, show many degenerative changes and necrosis, presenting a picture which in its entirety suggests a tissue of lowered vitality. That these facts alone would also exclude the probability that these growths would attain any appreciable size during the life of their carriers, even if permitted to remain a long time in the body, coincides with the observations of the cases.

The **histologically malignant character** of these tumors has

been attested to by all observers. As has before been mentioned the type of tumor cells follows in the main two varieties.

First, the most frequently found form is the spheroidal-cell carcinoma, or the so-called basal-cell cancer, which is recognized as a type characterized by its relatively slow growth, the absence of early metastasis and the lack of recurrence after operative removal. In this type the individual cells are epithelial in appearance, polyhedral or irregular in shape, possibly small, round or quite flattened where the cluster of cells draws to a point, their nuclei are vesicular and stain well, they occur in nests devoid of alveolar formation and with a marked tendency toward stroma development. Moreover this type as shown by Warthin is apt to be found in early life and is quite similar to the so-called basal carcinoma of the skin. The second type is that typical of intestinal carcinoma as it is seen elsewhere in the abdominal cavity, formed of columnar cells with the formation of a more or less distinct lumen. We see the cells arranged in nests, they are large and ovoid, others are elongated and narrow, their nuclei are clear, vesicular and stain well. The stroma is relatively inconspicuous as compared with the masses of tumor cells, the latter often seen as solid nests, the individual cells polyhedral in shape from mutual compression, they can again be found in double or triple layers, and elsewhere appear as hollow cylinders being composed of a single layer of cells surrounding a clear lumen.

The prevalence of the spheroidal cell variety of carcinoma is shown in the statistics of Rolleston and Jones. Also, McWilliams finds it the most frequent occurring variety, being present in 38 per cent. of his cases. The growth is usually located in the mucosa and submucosa or penetrating the connective tissue which replaces these layers in cases of obliterative appendicitis spreading its parenchyma cells as far as the meso-appendix but rarely giving other signs of malignancy characteristic of intestinal cancer, *i. e.*, metastases to the surrounding peritoneal surfaces in the vicinity of the growth, involvement of the neighboring glands of the mesentery or recurrence after operation.

When proliferation does not proceed from the obliterated areas, the submucosa appears to be the point of origin for infiltration, and spreading from thence the cells are found in the lymph spaces of the muscle layer, frequently in the subserosa of the appendix

and even the meso-appendix. Moreover these proliferations have no connection or traceable continuity with the glands or with the epithelium of the mucous membrane.

Metastases have been proved to occur in the cases of LeConte, A. T. Cabot, Beger, Harte (Case VIII), Whipham, Edington, Weir and White. While the cases reported by Voeckler and by Lejars had undoubted recurrences.

The theory has been advanced by Milner and others that these growths are endothelioma rather than carcinoma. The weight of opinion and evidence, however, are in favor of the belief that the constituent cells are of epithelial origin though an explanation of the peculiar benignancy of these growths as contrasted with other epithelial neoplasms is not yet forthcoming.

In 1909 Milner published an article in which he cast doubt upon the accuracy of the diagnosis of carcinoma of the appendix in practically all previously reported cases, especially in those occurring in comparatively young individuals. He attempted to prove that these neoplasms were of inflammatory origin and the products of hyperplastic chronic lymphangitis proceeding from proliferation of the endothelium of the lymph spaces, or else from pathological depressions of the mucous membrane. He based this on first, the apparent benign nature of the tumors and their frequent occurrence in the young, and secondly on the variations of morphology of the tumor parenchyma from the cylindrical cell epithelium of the neighboring intestines and its glands. He attempts to strengthen his position by the work of Orth and Borst on chronic lymph vessel inflammation associated with proliferation of the endothelium, and states that he has seen proliferation in actinomycosis that was histologically identical with carcinoma.

This work of Milner has stirred up quite a quantity of comment, but no one with the exception of Neugebauer, seems ready to accept his views. Sternberg, Bertel, Goetjes, Burkhardt, and Dietrich all hold that we cannot make a distinction, the latter saying that "we have in these small cell tumors of the appendix, associated with chronic and acute inflammation a characteristic tumor formation which anatomically must be recognized as undifferentiable from carcinoma." Voeckler says, after a thorough dissertation, "I must nevertheless contend, contrary to the views of Milner, that

these cases represent a true carcinoma," while Oberndorfer dismisses the subject with the remark that, "we are dealing with histological carcinoma, but biologically benign." In the study of the cases at the German Hospital we have been able to agree with the hypothesis of Milner in only one instance as to the origin of the new growth from the lymph endothelium. In this case, indeed, it is questionable whether we are dealing with an endothelioma rather than a simple hyperplastic lymphangitis. The remainder of the cases show in every instance what we considered to be evidences of derivation from epithelial cells.

It is noteworthy that with proper staining methods the products of secretion, or of degenerations of the cells themselves could be demonstrated to be mucin, a feature we have never observed in connection with endothelioma, and we feel that here we have to do with an epithelial tumor, which in form and arrangement of its cells, also in the manner of its proliferation has the character of a carcinoma, though the proof is lacking for their clinical malignancy through the formation of metastasis and the development of recurrences.

Sarcoma.—This type of tumor occurs as primary in the appendix but its rarity is shown by the fact that to the present but nine authentic cases have been reported (Wright). The growth is usually of the small round-cell variety or lympho-sarcoma. There is generally an early involvement of the cæcal wall and its degree of malignancy is unaltered. Sixty-six per cent. of the cases occurred in the male sex. A recent case of my own is of sufficient rarity and interest to deserve special mention.

The patient, P. H., aged thirty-nine years, a male of Russian extraction, a tailor by occupation, was admitted to the German Hospital April 4, 1912. His family and personal history was unimportant.

For two months before admission he had at times felt pain in the right loin of a dull aching character. He asserted that he had had pain on urination. He was nervous and troubled with headache. His appetite and digestion were good but he was inclined to constipation.

About one month previously the patient had discovered a lump in the right side of the abdomen. It had increased slowly in size. There was no history of injury or loss of weight.

The examination revealed nothing of note except in the right abdomen where a rounded mass the size of a large orange could be grasped with ease and moved

upward beneath the ribs, downward to the brim of the pelvis and inward almost to the median line. It felt semi-solid and was not painful or tender.

The urine was negative and examination for functional capacity by phenol-sulphonephthalein showed both kidneys to be normal. The blood showed Hgb. 75 per cent.; erythrocytes, 4,250,000; leucocytes, 12,400 with normal differential formula



FIG. 12.—MYXOSARCOMA OF APPENDIX AND MESO-APPENDIX.

At operation, April 15, 1912, the abdomen was opened anteriorly and an ovoid mass found attached to the tip of the appendix which served as a pedicle for the growth permitting a considerable range of motion. The appendix, and with it the tumor, was removed as in simple appendectomy.

Pathology.—The appendix measures 2.5 cm. in length, is somewhat thickened and fibrous but uniform in calibre. Its surface is moderately injected but no other gross abnormality is present in its proximal portion. The distal end is continuous with a globular mass measuring $13 \times 10 \times 8.5$ cm. The appendix is inserted tangentially giving the impression that the mass had arisen on the mesenteric side of the appendix. The growth is encapsulated, smooth, soft and resilient and everywhere covered with peritoneum. On section the surface is homogeneous, grayish, glistening and translucent with faint pinkish markings throughout.

Microscopically the tissue is seen to be composed of stellate embryonic connective-tissue cells with much delicate intercellular fibrillæ and a hyaline matrix. The cells vary considerably in size and are sometimes multinucleated. Often the nuclear material is not definitely outlined but is diffused throughout the cell. No definite mitotic figures are seen. The vessel walls are delicate, consisting often of endothelium only supported by the tumor tissue.

Microscopic Diagnosis.—Chronic interstitial appendicitis, myxosarcoma of appendix and meso-appendix.

THE PERITONITIS AND ITS CONSEQUENCES.

Although the dissociation of the lesions of the appendix from those of its serous covering (peri-appendicitis) and the peritoneum in general is at most artificial, there are several reasons, not alone of convenience, that render profitable the discussion of each separately. In the first place, similar lesions of the appendix, in different cases, may give rise to most diverse peritoneal lesions; that is, there is no constant relationship between the lesions of the appendix and those of the peritoneum. There can be no question that in certain cases of appendicitis the peritoneum presents no deviations whatever from the normal. These cases, however, are of comparative rarity, and are almost exclusively instances of catarrhal or mild inflammation. But not all cases of catarrhal appendicitis are unaccompanied by inflammation of the peritoneum. Again, there are still rarer cases of fulminating appendicitis with rapid gangrene, in which the diseased organ may be excised by the surgeon, or the patient may die before there has been time for the development of peritonitis. Further, instances of chronic interstitial appendicitis with ulceration, unattended by evidences of implication of the peritoneum, have been recorded by several observers, among them Schede and Sonnenburg. But these are unusual cases. Excepting the previ-

ously mentioned instances, all cases of appendicitis are complicated by peritonitis, and it is for this reason that the designation appendicular peritonitis is most appropriate. It is because of the peritonitis to which it gives rise that appendicitis acquires the importance that attaches to it.

The reasons for the implication of the peritoneum in appendicitis are not difficult to find. The peritoneal covering of the appendix is, in reality, a portion of the organ itself, and it is readily conceivable that an inflammation that affects one or more coats of a tube such as the appendix should, under favorable circumstances, affect all. That certain cases of catarrhal appendicitis are unattended by peritonitis is equally plausible. In these cases the operations of the noxious agents provocative of the catarrhal inflammation are confined to the mucous membrane, either because of their attenuation or of the resistance offered by the other tissues to their further progress. On the other hand, the factors for the ready dissemination of the inflammatory irritants are found in the virulence of the bacteria and their toxins and in the anatomical construction of the appendix. The liberal lymphatic supply to which Polya and Navratil have directed attention, and to a less extent the blood supply, must be held answerable for the conveyance of the irritants from one coat to the others.

The detection of bacteria in association with all varieties of peritonitis naturally led to the inference that there was some causal relationship between the former and the development of the latter. The demonstration experimentally that peritonitis follows the introduction into the peritoneal cavity of certain bacteria confirmed this view. The matter, however, is not so simple as at first sight appears.

In marked contrast to the opinions entertained some years ago, it has now been repeatedly demonstrated, both experimentally and otherwise, that the peritoneum is possessed of considerable powers of resistance to the action of all deleterious influences. These powers of resistance are comprised essentially in the following: (1) The bactericidal action of the peritoneal serum; (2) the great resorptive power of the peritoneum; (3) the marked tendency exhibited by the peritoneum to unite, to form adhesions, and cause circumscription—encapsulation of infectious foci. The first, the bactericidal action of the serum of the peritoneum, is probably of

little importance, though it seems that it should not be entirely ignored. The second, the great resorptive power of the peritoneum, is of considerable importance. Bacteria that gain access to the peritoneal cavity may be destroyed *in situ* by the bactericidal activity of the peritoneal serum, which, as stated, is not conspicuous, or they may be robbed in great part of their pathogenetic powers by their rapid resorption by the peritoneum. This, it seems, is of considerable moment, and there is good reason for belief, that, such is the rapidity with which bacteria are often absorbed by the peritoneum, they are removed from the peritoneal cavity before they have had time to exert sufficient deleterious activity to engender inflammatory reaction. Having been absorbed, they are finally destroyed by phagocytes in the lymph channels, blood-vessels, etc. Frequently, however, neither of these factors suffices, and, in an effort to resist general infection, the peritoneum exerts itself to the utmost by uniting, forming adhesions, and leading to encapsulation of infectious foci. The exact nature of this process is still imperfectly understood; but the fact is well established that, as bacteria in cultures may die as the result of the action of the toxin they themselves produce, so in such encapsulated foci the contained bacteria, after the lapse of a certain time, gradually lose their virulence and finally succumb; and that the cellular exudate undergoes various retrograde metamorphoses, becomes fatty, forms a granular débris, and is, partly at least, removed by absorption. It is not only the encapsulation and limitation of the infectious foci *per se*, but also the concomitant peritoneal lesions, that serve to protect against general infection. The obstruction of the lymphatic stomata and the regionary lymphatic radicles by the coagulated fibrin which also covers the serosa subserves the same useful purpose.

Appreciating the nature and character of the powers of resistance offered by the peritoneum, the comprehension of the mode of production of peritonitis is much facilitated. The introduction of non-pathogenic micro-organisms into a healthy peritoneum is without morbid consequences. The introduction of pyogenic micro-organisms into a healthy peritoneal cavity is not followed by peritonitis, provided the bacteria be not excessive either in number or in virulence. Peritonitis, however, does result from the access of pyogenic bacteria to the peritoneum when the bacteria are

excessive in number or virulence or both; that is, when there are excessive demands upon the resorptive power of the peritoneum, be it that there is a sudden accession to the peritoneum of a large quantity of bacteria, or an intermittent or continuous supply of bacteria in small numbers; when the resorptive power of the peritoneum is below the normal; when the peritoneal cavity contains a quantity of fluid, particularly an albuminous fluid susceptible of decomposition—even a simple ascites is of significance—when the peritoneum is subjected to mechanical injury at the site of the introduction of the bacteria, such as occurs in case of operative wounds and rupture of intra-abdominal organs, as the appendix, etc.; and when the patient is debilitated.

The disastrous consequences of peritonitis are due in part, particularly in the purulent varieties, to the local suppuration, to the loss of the bodily fluids, but in great part to intoxication of the general organism. The paramount importance of this latter is evident from the fact that the most severe and rapidly fatal forms of peritonitis are unaccompanied by the formation of any appreciable exudate; hence they are not attended by loss of the bodily fluids. The clinical manifestations of the severe forms of this affection—such as disturbed cerebration, partial coma or delirium, pale and “leaky” skin, cyanosis of the lips and finger-tips, dry tongue, rapid and fleeting pulse, rapid and shallow breathing, etc.—are the manifestations of intoxication rather than of infection. The different varieties of peritonitis, however, present marked differences in the degree of accompanying intoxication. Thus, in many of the cases of circumscribed peritonitis the intoxication is but slight. In some of the suppurative forms with gangrene of the appendix it may, however, be quite marked. Of the diffuse forms of peritonitis, those attended by the formation of pus, though extremely virulent and producing marked toxæmia, are less virulent and give rise to a less degree of toxæmia than do the hæmorrhagic forms and those marked by the absence of exudate. The latter, which may be designated toxic peritonitis, is accompanied by so extreme a degree of toxæmia that the patient generally succumbs very quickly. The shock attendant upon the rupture of the diseased appendix is of itself not of so much significance in the sudden development of alarming symptoms as is the rapid absorption of a

large quantity of preformed toxins that are suddenly evacuated into the general peritoneal cavity. It is under such circumstances that the great resorptive power of the peritoneum, of such significance in guarding against infection, becomes the very agent whereby the system is suddenly overpowered by a large quantity of these preformed toxins. The absorption also of a quantity of ptomaines that are sometimes liberated with the toxins contributes to the production of alarming symptoms. At times, of course, the fatal issue is determined by pyæmia rather than by intoxication.

Pathologically, the lesions of the peritoneum, like those of the appendix, may be acute or chronic as regards their course; circumscribed or diffuse as regards their extent; and serous, sero-fibrinous, fibrinous, purulent, or hæmorrhagic as regards their character. Just as in the different varieties of appendicitis, there may also be all gradations, from the mildest peritoneal implication to the most virulent—from those with slight circumscribed serous exudate to the most severe, malignant, generalized, purulent, hæmorrhagic, or toxic peritonitis. Nevertheless, there are attending the various forms of appendicitis several varieties of peritonitis which differ as to their mode of production, extent of implication of the peritoneum, and character of the exudate, and which, in consequence, permit of a practical classification of the peritoneal lesions of appendicitis. These will be described as follows:

I. Acute Appendicular Peritonitis.

1. Circumscribed serous, sero-fibrinous, and fibrinous peritonitis.
2. Circumscribed purulent peritonitis, or peri-appendicular abscess.
3. Diffuse or generalized peritonitis.

II. Chronic Appendicular Peritonitis.

ACUTE APPENDICULAR PERITONITIS.

CIRCUMSCRIBED SEROUS, SERO-FIBRINOUS, AND FIBRINOUS PERITONITIS.

By serous or sero-fibrinous peritonitis is understood an inflammation of the peritoneum attended by the formation of a serous or sero-fibrinous exudate. Of all the varieties of peritonitis com-

plicating appendicitis, the serous is probably the most infrequently met with, and, in consequence, but little attention has been directed to it. Its apparent uncommon occurrence is due not so much to its actual non-existence as to the fact that at the time of observation, either at operation or necropsy, it has given way to one of the severer forms of peritonitis. As a result, however, of the practice that has obtained in recent years of operating early in cases of appendicitis, sufficient opportunity has been afforded to note the not uncommon occurrence of such serous or sero-fibrinous peritonitis.

It is but natural to infer that if the peritoneum be implicated in a mild attack of appendicitis, the lesions of this structure, particularly in the early stages, will also be mild. For this reason it cannot be doubted that some at least of the severer forms of peritonitis, particularly the fibrinous (non-suppurative) form, and even also some of the purulent variety, are initiated as a serous or sero-fibrinous inflammation. The peritonitis, however, in many of these cases, either because of the virulence of the irritant or its long-continued action, does not remain of this character, but speedily progresses to the fibrinous or purulent variety.

Serous or sero-fibrinous peritonitis is encountered in association with the milder forms of appendicitis only—acute catarrhal and mild interstitial appendicitis and the chronic forms of the disease with mild, acute exacerbations. Under such circumstances the peritoneum covering the appendix is in a state of inflammatory hyperæmia. It is injected, many of the vessels being quite distended and visible to the unaided eye, while other minute ones, by their congestion, lend a diffuse redness to the tissue. In addition, the peritoneum has lost its normal lustre, is slightly opaque, and is somewhat rough, velvety, or viscid to the touch. This latter characteristic is dependent upon the presence of a serous or sero-fibrinous exudate that, at times, is so slight as to be scarcely appreciable. Occasionally rupture of minute blood-vessels occurs and leads to hæmorrhagic foci. These alterations, as a rule, do not extend beyond the limits of the peritoneal covering of the appendix. Exceptionally, they may also implicate the meso-appendix, and more rarely the cæcum, adjoining coils of intestine, and the parietal peritoneum. In certain isolated instances there may be in the neighborhood of the appendix a small collection of serous fluid.

Sonnenburg in particular believes in the occurrence of such serous peritonitis, and states that even large collections of serous exudate may be encountered. He records one case in which, at operation, he found a large exudate, consisting of turbid fluid free from bacteria, surrounded by a fibrous capsule, in the neighborhood of a chronically inflamed appendix. The occurrence of such circumscribed serous exudates is also spoken of by Roux, Lennander, Kümmel, Frankfurter, Renvers, and others. Nor can it be denied that some at least of them may have been originally sero-purulent, and in the course of time have become more serous and sterile as a consequence of the demise of the contained bacteria.

Fibrinous peritonitis is but an aggravation or further stage of the serous or sero-fibrinous variety of inflammation. It is found in association with acute catarrhal and interstitial appendicitis of moderate intensity, and with cases of chronic appendicitis in which there have been recurrences, the most recent one of some intensity. It is quite likely that in some cases in which an early operation discloses merely fibrinous peritonitis, a later or deferred operation would reveal progression to fibrino-purulent peritonitis, with or without perforation of the appendix.

In cases of fibrinous peritonitis the peritoneum in the region of the appendix is covered with a layer of fibrinous deposit of a grayish or grayish-yellow color and viscid to the touch. This is intimately adherent to the underlying peritoneum, and varies considerably in amount in different cases. At times it is excessively thin and watery, from the admixture of much serum and relatively little fibrin, and differs but little from the ordinary sero-fibrinous exudate. Again, there may be little serum and great amounts of fibrinous deposits. In the same case, also, the amount of fibrinous exudate may vary in different regions. Through the medium of this fibrinous or plastic exudate the appendix and the neighboring coils of intestine are more or less firmly united to each other and to the omentum and parietal peritoneum. After the separation of adherent coils of intestine the exudate may be stripped off in successive layers, revealing the peritoneum markedly congested, roughened, and lustreless. At times the exudate is so excessive that to locate the appendix requires more or less extensive dissection. Sometimes the appendix still eludes detection, and is found

only after diligent search embedded in a dense amount of coagulated lymph that may surround it to an extent of from one to three centimetres.

Upon microscopical examination of the peritoneum in cases of serous, sero-fibrinous, or fibrinous peritonitis, dilatation and over-filling of the blood-vessels, proliferation of the endothelial cells lining the peritoneum, serous infiltration of the fibrous layer of the latter, and more or less round-cell infiltration are detected. On the outer layer of the peritoneum there is a deposit of fibrin, which, of course, varies in amount in different cases. It commonly presents itself as a fine network that forms a support for the proliferating endothelial cells and wandering leucocytes. Occasionally, also, newly formed capillaries are detected. The cells of the network undergo various degrees of retrograde metamorphosis, and at times rupture of the newly formed capillaries ensues and gives rise to hæmorrhagic foci. The serous fluid usually contains a few flocculi of coagulated lymph, and, even when quite clear, reveals microscopically a number of lymph corpuscles and desquamated endothelial cells.

In case this fibrinous peritonitis does not progress to suppuration, evidences of organization become manifest. The fibrinous network acts as a support for newly formed connective-tissue cells and capillaries. This granulation tissue, through the well-known processes of regeneration, is transformed into fibrous connective tissue that speedily undergoes cicatrization. Thus chronic peritoneal adhesions and bands, of which mention will be made subsequently, result.

CIRCUMSCRIBED PURULENT PERITONITIS, OR PERI-APPENDICULAR ABSCESS.

The most common peritoneal complication of acute appendicitis, and clinically the most important, because of its disastrous consequences, is circumscribed purulent peritonitis—the formerly so-called perityphlitic abscess. Just as a severe interstitial or ulcerative appendicitis may follow a catarrhal or a mild interstitial inflammation, so circumscribed purulent peritonitis may be an aggravation of a milder variety of peritoneal inflammation, and may follow in the sequence of a serous, a sero-fibrinous, or a fibrin-

ous peritonitis. Thus, it is found in association with interstitial appendicitis without perforation, with ulcerative appendicitis without perforation, and it is always a concomitant of ulcerative appendicitis with perforation, unless the peritoneal involvement be diffuse. The peritonitis of gangrenous appendicitis is also of the purulent variety. Again, the acute infection or exacerbation of the inflammatory phenomena of a chronically inflamed appendix may be the starting-point of a circumscribed peri-appendicular abscess.

The serous and fibrinous exudates already described in connection with serous, sero-fibrinous, and fibrinous peritonitis are to be interpreted as the results of the reaction of the peritoneum to the action of an irritant—as an effort on the part of the peritoneum to protect itself from general infection. This exudate thus subserves a useful purpose. More than this, in the event of perforation of the appendix—the perforation in the majority of cases occurring into, rather than outside of it—it has already formed a barrier that in most instances, for a time at least, prevents infection of the general peritoneal cavity. It is, however, not essential that perforation occur in order that an abscess result. An exudate originally fibrinous often becomes fibrino-purulent or purulent without perforation of the appendix developing.

In circumscribed purulent peritonitis, or peri-appendicular abscess, a greater or smaller portion of the peritoneal cavity lodges a focus of suppuration that develops at the site of the original source of infection and is walled off from the general peritoneal cavity by more or less firm fibrino-plastic exudate. This peri-appendicular abscess may develop slowly or exceedingly rapidly, and in different cases it varies much in size and in other characteristics. There may not be more than one or two cubic centimetres of pus, in which case the abscess may be difficult to find; on the other hand, the abscess may be exceedingly large, and may contain upward of a litre of pus. Usually, however, in an ordinary case there are not more than thirty cubic centimetres of pus. The abscess may be single or multiple, and may be regular or irregular in outline. It is not rare to find several pockets of pus that communicate with a common cavity. Under other circumstances several isolated pockets may communicate with one another by narrow and tortuous channels.

The wall of the abscess cavity is made up of a grayish-yellow

or yellowish-green discolored fibrino-purulent exudate. This is of variable firmness and consistency, and serves to unite more or less securely the appendix, cæcum, neighboring coils of intestine, omentum, mesentery, and parietal peritoneum. The pus is sometimes yellowish in color and distinctly creamy in appearance. More commonly, however, it is thinner than cream, of a yellowish-green, brownish, or greenish-black color. Sometimes it is bluish or greenish in color, and under such circumstances may reveal *Bacillus pyocyaneus* in pure culture. It usually possesses a peculiar, penetrating, disagreeable, fæcal odor. At times it is distinctly putrid, and may contain gas, the latter the result of the activities of contained bacteria or of admixture of intestinal gases in cases of perforation. In addition to the pus, the abscess may contain more or less necrotic remnants of fibrinous exudate, one or more fæcal concretions, and some fæcal matter. In it also we may detect the more or less altered appendix. The appendix, in whole or in part, may appear suspended, as it were, in the abscess cavity, or it may have become entirely separated from its cæcal attachment by circular amputation, and may float entirely free in the pus. More commonly it will be found embedded in the exudate forming part of the limiting wall of the abscess.

The situation of the abscess varies greatly in different cases, and is naturally dependent to a considerable extent upon the situation, the direction, the length, the mobility, and the possible fixation of the appendix. In exceptional cases the appendix and the cæcum are found in anomalous positions, which in the event of appendicitis exert considerable influence in determining the situation of possible peri-appendicular suppuration. In the majority of cases, however, it is possible to divide these abscesses, with respect to their situation, into certain groups, of which Sonnenburg distinguishes four that are of common occurrence: (1) Anteriorly; (2) posteriorly; (3) medianly; (4) in the pelvis. In the first, according to him, there at first occurs an adhesion of the coils of intestine that normally are almost always found in front of the cæcum. Beneath these the abscess originates. As it increases in size, the adherent coils of intestine are displaced and the pus reaches the parietal peritoneum. The latter thus forms the anterior boundary of the abscess, the cæcum the posterior and median boundary, and the iliac fossa the outer

boundary. In addition, various coils of intestine may assist in the limitation of the abscess above. In these cases the appendix is usually found anteriorly in the iliac fossa or attached to the outer or lower surface of the cæcum. When situated posteriorly, the abscess is limited anteriorly by the posterior surface of the cæcum, and posteriorly by the posterior abdominal wall. In these cases the appendix is usually attached to the posterior surface of the cæcum and is directed upward. These abscesses are situated higher than those of the former group, and, spreading out in the region of the kidney, they may give rise to perirenal suppuration; or, reaching the lumbar region, they may cause protrusion of it. Abscesses situated medianly are bounded laterally or externally by the median aspect of the cæcum and ascending colon; posteriorly, by the meso-colon; mesially, anteriorly, and above, by various coils of intestine. Attaining a considerable size, these abscesses may reach to, and be limited by, the bladder. Abscesses situated in the pelvis commonly occupy the right half of it, though they frequently extend also to the left. They are often situated in the retro-vesical space—in women, in Douglas's *cul-de-sac*. The appendix is usually detected in the upper and outer wall of the abscess; frequently, however, it may be adherent to the bladder, uterus, tubes, ovary, rectum, etc. This classification had been adopted independently by Deaver, who, in addition to describing the foregoing four varieties of peri-appendicular abscess, is in the habit of speaking of a fifth variety—the diffuse abscess, or diffuse purulent peritonitis. As already intimated, these peri-appendicular abscesses may be encountered in most unusual situations. Of such may be mentioned: Near the gall-bladder, near the spleen, in the region of the umbilicus, beneath the right lobe of the liver, beneath the diaphragm, in the left iliac fossa, in a hernia—inguinal or femoral, of either the right or left side—etc.

Heretofore mention has been made only of the suppurative complications of appendicitis that occur within the peritoneal cavity—to circumscribed appendicular peritonitis. It must, nevertheless, be stated that, in the event of suppuration ensuing upon an attack of appendicitis, it is not necessary that the collection of pus be situated primarily within the peritoneal cavity. The abscess may be retro-peritoneal—the formerly so-called *para-typhlitic abscess*. This may be due to one of several causes: (1) It may occur if the appendix

be situated retro-peritoneally, as happens, as has been mentioned already, in about 2 per cent. of the cases. In case infectious material penetrate the wall of the appendix, or if perforation of the organ occur, the retro-peritoneal connective tissues are those first attacked, and a retro-peritoneal abscess results. (2) Such may also develop, although the appendix be situated intra-peritoneally, if the perforation occur into the meso-appendix. Under such circumstances the liberated infectious material dissects its way between the two layers of the meso-appendix, and finally reaches the retro-peritoneal connective tissues, where the abscess originates. It is quite likely also, that, in the absence of perforation, some retro-peritoneal abscesses may be produced by virulent infectious material being carried by the lymphatics of the meso-appendix to the retro-peritoneal connective tissues. (3) Such retro-peritoneal suppuration may also occur in some cases in which rather firm adhesions bind the appendix to the posterior layer of the peritoneum. In these cases this posterior layer of the peritoneum may have become so altered by the inflammation that, in the event of perforation, it offers but little resistance to the advances of virulent bacteria and their toxins. Being less resistant than the firm adhesions, it gives way first, and there thus occurs a perforation of the appendix, directly through its peritoneal coat, some adhesions, and the posterior layer of the peritoneum, into the retro-peritoneal connective tissues. A retro-peritoneal abscess results, without any associated intra-peritoneal suppuration. (4) Retro-peritoneal abscesses may occur secondarily by perforation through the posterior layer of the peritoneum of an abscess that originated intra-peritoneally.

Such retro-peritoneal abscesses sometimes give rise to the most extensive phlegmonous infiltration. Following the course of the iliac vessels, they may present themselves beneath Poupart's ligament; they may involve the region of the kidney and engender a large perirenal abscess, with or without implication of the kidney; they may ascend behind the liver and spread out over its surface, producing an extensive subdiaphragmatic abscess; they may perforate into the pleura and produce an empyema; they may penetrate the lung and give rise to a pulmonary abscess, that may or may not be expectorated externally; they may perforate again into the peritoneal cavity, etc.

Reverting again to peri-appendicular abscess situated primarily within the peritoneal cavity, it will be recalled that it was stated that it may attain a capacity of a litre. Such an occurrence, however, is most exceptional. Usually, if the abscess be progressive, before it has attained such a size one of several events will have ensued. There will either have been produced a diffusing peritonitis—of which mention will be made later—or, if the adhesions be sufficiently firm to protect the general peritoneal cavity from infection, the abscess will probably have ruptured in one of several directions. As the abscess increases in size it not only compresses the adjacent organs and tissues, but the latter themselves become the seat of more or less superficial or deep inflammation with purulent infiltration and necrosis. The various organs and tissues of the region of the appendix permit of a certain amount of compression without much resentment, but when the limit has been reached, the abscess of necessity ruptures in the direction of least resistance. As some of the organs of this region, because of their implication in the inflammation, are themselves the points of least resistance, it is into them that rupture often occurs. Certain organs, however, are much more likely to be the seat of such perforation than others. The relative frequency of perforations into different tissues and organs is indicated by Sonnenburg, who cites the reports of various observers. These include a total of 424 cases, the combined statistics of Bull, Langheld, Einhorn, Krafft, and Paulier. Collectively, the most frequent perforations were as follows.

Through the abdominal wall.....	46
Into the cæcum.....	40
Into the peritoneal cavity.....	8
Into the pleural cavity.....	6
Into the ascending colon.....	4
Into the rectum.....	4
Into the ileum.....	3
Into the bladder.....	3
Into the uterus.....	1

It was misconception of the real direction of the perforation in certain cases of peri-appendicular abscess that, in part at least, led to the erroneous view maintained some years ago, that appendicitis was typhlitis, perityphlitis, and para-typhlitis, and that the suppurative forms of the latter were the result of perforation of the cæcum.

Suppurative disease about the cæcum did not, as was then held, result from disease and perforation of the cæcum. On the contrary, perforation of the cæcum, in many of these cases, was due to rupture into the cæcum of an already formed peri-appendicular abscess; in other cases it was due to a direct rupture of the appendix into the cæcum, with which it had formed adhesions. There occur, however, cases of perforation of the cæcum due to some morbid condition of that viscus, such as large enteroliths, etc.

In addition to the previously detailed directions of rupture of peri-appendicular abscesses rare instances of perforation into other organs have been encountered. Thus, cases have been reported in which the abscess ruptured into the gall-bladder, into the duodenum, into the vagina, into the ureter (pelvis of the kidney), etc.; and Sonnenburg mentions a case in which, probably through infection of a patulous vaginal tunic of the testicle, there resulted a pyocele of the testicle.

But other secondary disastrous consequences ensue upon the persistence of the abscess. Thus, lymphangitis and lymphadenitis, thrombo-phlebitis and pylephlebitis may occur. The thrombo-phlebitis usually affects the mesentery and portal veins, but thrombosis of the iliac and femoral veins of either the right or the left side, or of both, may develop. The pylephlebitis is sometimes of the mild or non-infectious variety—the so-called adhesive pylephlebitis—in which the thrombus leads to partial or complete obliteration of the portal vein. Frequently, however, the process is infectious; the thrombus becomes purulent and leads first to abscess of the liver, and subsequently to general infection, or pyæmia. Again, erosion of a principal branch of the mesenteric vein has been encountered (Aufrecht), and implication of a branch of the inferior vena cava, with consecutive pulmonary abscesses, is not unknown. Of other conditions secondary to the abscess may be mentioned: Erosion of the internal iliac artery or of one of its branches; iliopsoitis; peri-hepatitis; suppurative pleuritis; endocarditis; parotitis; meningitis; abscess of the kidney, spleen, etc.; disease of the female genitalia; and general septicæmia, pyæmia, etc.

It cannot be denied, however, that, under exceptional circumstances, absorption of pus may occur. This is, nevertheless, a very rare event, and ensues only when the abscess is very small and the

virulence of the contained bacteria very slight. Under such circumstances the abscess gradually becomes sterile, then inspissated, and there may result the formation of a thick mass of indurative connective tissue which rarely has been found the seat of calcareous infiltration. Under other circumstances the abscess may remain fluid and encysted—surrounded by a firm connective-tissue capsule.

Of recent years, as the nature of appendicitis is becoming more thoroughly appreciated, and the appropriate treatment more generally undertaken, the previously detailed disastrous complications are becoming progressively less. The more universal become the early recognition and the prompt surgical evacuation of appendicular and peri-appendicular suppuration or the removal of the diseased appendix before the supervention of suppuration, the less frequent are the secondary results of such collections of pus. It is for this reason that they whose practice it is to operate early in cases of appendicitis do not meet with these complications so frequently as do they who delay operation.

DIFFUSE OR GENERALIZED PERITONITIS.

In diffuse or generalized peritonitis the entire, or almost the entire, visceral and parietal peritoneum are involved in the inflammatory processes. Such peritonitis may develop in a variety of ways, and its pathological anatomy differs considerably in different cases. It is found associated with severe cases of acute interstitial appendicitis without perforation, with ulcerative appendicitis with or without perforation, and with gangrene of the appendix. Several types of diffuse or generalized peritonitis may be distinguished, and a classification may be based not only upon the character of the pathological alterations, but also upon the manner of their production.

Thus, there is a form that may develop by gradual progression from a circumscribed purulent peritonitis—the *progressive fibrino-purulent peritonitis of Mikulicz*. This variety of general peritonitis is the slowest of all forms in its diffusion. From the original focus of infection, which may be a peri-appendicular abscess or a small perforation—the perforation occurring at a time when limiting adhesions have not yet formed—the entire peritoneum, step by step, as

it were, becomes implicated. As this occurs, each new portion that is affected becomes walled off from the remaining unaffected peritoneum by more or less firm adhesions, in a manner similar to that which limits the original infectious focus or surrounds the appendix before it has perforated. These adhesions, which may unite portions of the intestine and omentum with any of the abdominal organs or with the parietal peritoneum, thus serve to protect the remaining peritoneum from sudden infection. These adhesions, in the majority of instances, are at first purely fibrinous in nature. However, they speedily become fibrino-purulent and purulent, and there are thus formed, in various portions of the peritoneum, pockets of pus that are more or less separated from one another. Some of them are entirely isolated, but many of them may communicate with one another by more or less tortuous channels. Gradual leakage of the infectious material occurs, additional portions of the peritoneum are involved, new adhesions (limiting barriers) are found, new foci of suppuration develop, until finally the entire peritoneum may become implicated. It is rather uncommon to find the entire peritoneum involved; there usually remain larger or smaller areas that seem to have resisted the onslaughts of the infection, and these are always separated from the affected peritoneum by the fibrinous wall. Careful search is sometimes necessary not only to detect these unaffected regions, but also to determine the situation of some of the pockets of pus.

In another series of cases there occurs a *diffuse* or *generalized purulent* or *suppurative peritonitis* without noteworthy fibrinous exudate, and consequently with but slight and friable adhesions between the coils of intestine, omentum, abdominal organs, and parietal peritoneum. Such peritonitis develops when perforation of the appendix occurs suddenly and soon after the onset of the disease—at a time when the peritoneum has not yet had time to form a plastic exudate; when a large and ill circumscribed empyema of the appendix suddenly bursts; when there occurs a sudden gangrene of an appendix that is not well surrounded by adhesions; and when, for any reason the adhesions limiting a peri-appendicular abscess suddenly give way and liberate a large quantity of pus. Thus, the peritoneal lesions vary somewhat, depending upon whether the ulcerative processes in the appendix, and consequently

the perforation, develop slowly or rapidly. If the former, the peritoneum has had time to form a greater or less amount of plastic exudate that completely surrounds the appendix, and, in the event of perforation, a circumscribed peritonitis or abscess results, as has already been detailed. If the perforation develop suddenly, the appendicular contents are poured forth into the free peritoneal cavity. The intensity of the resulting inflammatory lesions depends upon the amount, the fluidity, the virulence, and the rapidity of the evacuation of the appendicular contents. These, having gained access to the general peritoneal cavity, are rapidly dispersed through extensive portions of the peritoneum by the peristaltic action of the intestines, and a diffuse purulent peritonitis ensues.

In this variety of inflammation the peritoneum is the seat of an intense inflammatory hyperemia; it is opaque and lustreless, and is covered with a small amount of a grayish-yellow or yellowish-green, veil-like, slimy, viscid exudate. These lesions, as a rule, are not distributed with uniformity throughout the peritoneum, but are commonly more marked near the seat of infection. It is not unusual, however, to find them affecting the peritoneum of the small and large intestines, the omentum, the mesentery, the solid abdominal organs, and the abdominal wall. The slight amount of exudate may serve loosely to unite neighboring loops of intestine, but, as a rule, there are no firm adhesions unless they be old. The exudate, being attached loosely, often appears as a shredded covering of the intestine, and the unattached ends of the shreds can frequently be detected floating upon the surface of the pus contained within the peritoneal cavity. At times these shreds become entirely detached from the intestine and float free in the pus. The pus varies considerably in different cases. At times there is relatively little; again, the amount is excessive—a litre or more, and this within a short time of the onset of the attack. For a time, at least, it is freely movable, and, following the laws of gravity, seeks the dependent portions of the peritoneal cavity—recesses between adjoining coils of intestine, the pelvis, and the prerenal regions. Later, if some adhesions are formed, there may occur more or less circumscribed collections of pus in various other regions. In character the pus is rarely thick and creamy; it is usually rather thin, limpid, of a greenish-yellow color, at times of a brownish tint, and of a distinctly fæcal odor.

At times this variety of peritonitis assumes markedly putrid characteristics—*putrid peritonitis*. The peritoneum is swollen, congested, softened, and of a turbid grayish or grayish-red, opaque color. The exudate is usually rather small in amount, of a turbid grayish, grayish-red, or grayish-brown color, and exceedingly malodorous. At times it may contain gas, even in the absence of perforation of the appendix. This is of most unusual occurrence; but despite the prevailing differences of opinion, it cannot be denied that certain gas-forming bacteria may penetrate the diseased wall of the appendix and give rise to the formation of gas in the peritoneal cavity, even in the absence of perforation of the appendix. As a matter of fact, however, this variety of peritonitis is usually found in association with gangrene of the appendix with perforation. As a consequence, the production of gas is readily explicable, as is also the fact that at times portions of the gangrenous appendix, a faecal concretion, or rarely, a foreign body can be detected free in the peritoneal pus.

Under other circumstances the peritonitis assumes a hæmorrhagic character—*hæmorrhagic peritonitis*. The peritoneum is excessively congested and the seat of more or less extensive hæmorrhagic suffusions. There is also some admixture of blood with the purulent or sero-purulent exudate, which gives it a reddish or brownish color. Otherwise the lesions do not differ from those already detailed.

The last-named varieties of peritonitis are closely allied to that even more rapidly fatal form known as *septic peritonitis*, or *peritoneal sepsis*. In view of the fact, however, that the symptoms and pathological lesions of none of the varieties of peritonitis are unassociated with the activities of bacteria, the reservation of the term septic—a term variously interpreted at present—to designate a certain class of inflammations of the peritoneum is open to objection. As the clinical and pathological features of this variety of peritonitis are due to the rapid absorption of a large quantity of virulent toxins, it may be preferable to designate it *toxic peritonitis*. Clinically, the predominating characteristics of this variety are not only the evidences of disease of the peritoneum, but also, and particularly, the indications of profound intoxication, which, as is well known, manifest themselves principally by disturbances of the nervous system and of the general economy. Pathologically, cases

of this class differ from those of the other classes by the relative meagerness of the lesions. In the other varieties of peritonitis the peritoneum is able to offer some resistance to the spread of the infection, and this resistance is manifest by the evidences of inflammation and the attempts at restriction of the infectious focus to a portion of the peritoneum. In cases of toxic peritonitis, however, the peritoneum, and secondarily the general economy, are suddenly overwhelmed with such a quantity of virulent toxins that the patient may succumb before the peritoneum is able even partly to recover itself and to attempt an adequate resistance.

The lesions detected in these cases are often inconspicuous. Aside from injection of the peritoneum, either in whole or in part, there may be no deviations from the normal. In other cases the congestion may be more intense and widespread, and there may be minute hæmorrhages beneath the serosa; in addition, the peritoneum may be a little less glistening than normally, and there may be a slight amount of free fluid. The latter is usually small in amount, thin, limpid, and of a yellowish-green color and somewhat malodorous. At times the peritoneum is quite dry. There may also be a diffuse, infectious, serous peritonitis, as described by Tietze. Under other circumstances portions of the intestine may be distended, whereas others may preserve their normal calibre. Here and there a few fibrinous flakes may be seen, but firm adhesions are never encountered. The spleen is enlarged and there is cloudy swelling of the liver, kidneys, heart muscle, etc.

CHRONIC APPENDICULAR PERITONITIS.

If an attack of sero-fibrinous or fibrinous peritonitis complicating appendicitis take a favorable course—that is, do not go on to suppuration—or if the appendix be not removed by operation, the exudate, as has already been intimated, undergoes the ordinary alterations characteristic of the formation of fibrous tissue. There thus result bands of adhesions that unite the appendix, portions of intestine, omentum, mesentery, and parietal peritoneum. The longer the affection of the appendix has continued, and the more numerous and severe have been the recurrences, the more certain are peritoneal adhesions to be found, and the more firm and

extensive are they likely to be. After the removal of the diseased appendix by operation the remaining exudate always tends to organization and cicatrization.

The macroscopical appearances in cases of chronic peritonitis vary somewhat, depending upon whether the examination be made during a recurrence or during the interval between attacks. Generally, however, the appendicular peritoneum—usually, also that of the meso-appendix—is congested, thickened, opaque, and harder than normal. The appendix is more or less firmly united to the cæcum, colon, omentum, intestine, mesentery, parietal peritoneum, or some of the viscera by means of bands of adhesions that vary much in thickness and firmness. They may be slight, long, much attenuated, and readily broken, or they may be short, very thick, and exceedingly dense and fibrous. Not only is the appendix often united to the structures just enumerated, but the latter are themselves frequently firmly united with one another. A portion of the omentum, the appendix, and a loop of intestine may, with adhesions, form so dense a mass that only careful search reveals the situation of the appendix, and the most painstaking dissection is requisite to remove it. This may also be true of the cæcum and of other portions of the intestine, which are often bound down, twisted, constricted, and dislocated by bands of adhesions of various characteristics.

The associations that the appendix forms with other organs by the medium of these bands naturally depend upon its situation, and this, in certain cases, is not independent of the great mobility of the organ. In its ordinary situation the appendix is, of course, most frequently united with the cæcum; then, in order of frequency, the peritoneum of the right iliac fossa, the mesentery, the small intestine (ileum), the omentum, and the colon. In women it is often adherent to the right uterine adnexa. When in unusual situations, or when excessively long and motile, the appendix may have formed adhesions with almost any of the intra-peritoneal organs—the duodenum, gall-bladder, liver, spleen, ureter, bladder, rectum, left uterine adnexa, etc.

These adhesions are of varying importance. If they be small, of slight extent, and yielding, they may be devoid of portentous significance. On the other hand, they are commonly distinctly detrimental to health. They contribute to renewed attacks of ap-

pendicitis by restricting the free motion and the peristaltic action of the appendix, and by causing compression, strictures, twists, angulations, etc., of the organ. In addition, they often engender the most disastrous intestinal conditions. By their mere adhesion to portions of the bowel they inhibit peristalsis, and by their contraction they may, by compressing or encircling the bowel, cause intestinal obstruction, angulation, or strangulation. They may also compress the ureter and give rise to hydronephrosis and pyonephrosis, and produce a variety of clinical manifestations by reason of their connection with the liver, spleen, bladder, ovary, etc. Von Frisch in an interesting study of cases of appendicitis associated with a hematuria reports a case of his own and one of von Amstel where the blood was seen at cystoscopy to be coming from the left ureter and associated with a tumor mass in the left loin. An exploratory laparotomy showed the tumor to be due to angulations of the splenic flexure caused by adhesions of appendiceal origin, the tumor mass pressing on the kidney pedicle creating sufficient congestion in this organ to cause a hematuria. Adhesions on the contrary, are not altogether without value. Contributing, as they do, to recurrences of appendicitis, in the event of such developing and perforation ensuing they have formed a barrier that, for a time at least, effectually prevents infection of the general peritoneal cavity. Theoretically, at least—especially if they surround the appendix or bind it to the wall of the pelvis—as they contract they assist in the constriction and obliteration of the lumen of the organ. If the latter occurs, the likelihood of recurrence of the inflammation is excluded.

The frequency of these adhesions is indicated by the statistics of Leichtenstern, who found, among 1541 cases of intestinal obstruction, 34 resulting from disease of the appendix.

THE BACTERIOLOGY.

As the basis of a discussion of the pathogenetic rôle of bacteria in appendicitis the results of the bacteriological investigations of 286 appendices removed by operation may be detailed. The first inoculation in each case was made from the lumen of the appendix after aseptic incision of its wall, and the inoculation was always made from the seat of most manifest disease. At times inoculations were also made from the exudate on the peritoneal

surface of the appendix, from pus of the abscess, from free pus in the peritoneal cavity, and from drainage fluid subsequent to the operation. The results of these later inoculations in no cases differed from those of the primary inoculations from the lumen of the appendix. Inoculations in the first place were made into bouillon or into agar tubes, or both. Subsequently, in many of the cases, Petri-dish cultures were made, and later various other inoculations, for the purpose of fully establishing the identity of the bacteria under investigation. In some instances, also, cover-slip preparations were made directly from the pus or other contents of the lumen of the appendices, from the exudate on the peritoneal surface, or of the free pus. Of the 286 appendices examined bacteriologically, 128 were instances of acute appendicitis; 158 of chronic appendicitis. The results of the examinations may be tabulated as follows:

Acute appendicitis:

Bacterium coli commune alone.....	93 cases (72.656 per cent.).
Bacterium coli commune and Staphylococcus pyogenes aureus.....	17 cases (13.28 per cent.).
Bacterium coli commune and Streptococcus pyogenes.....	6 cases (4.69 per cent.).
Bacillus pyocyaneus alone.....	6 cases (4.69 per cent.).
Staphylococcus pyogenes albus alone.....	3 cases (2.344 per cent.).
Staphylococcus pyogenes aureus alone.....	1 case (0.78 per cent.).
Bacterium coli commune and Staphylococcus pyogenes citreus.....	1 case (0.78 per cent.).
No growth.....	1 case (0.78 per cent.).
<hr/>	
Total.....	128 cases (100.00 per cent.).

The following were the results of the bacteriological examinations in the cases of chronic appendicitis:

Bacterium coli commune alone.....	142 cases (89.873 per cent.).
Bacterium coli commune and Staphylococcus pyogenes aureus.....	7 cases (4.43 per cent.).
Bacillus pyocyaneus alone.....	2 cases (1.266 per cent.).
Bacterium coli commune, Staphylococcus pyo- genes aureus, and Staphylococcus pyogenes albus.....	1 case (0.633 per cent.).
Staphylococcus pyogenes aureus alone.....	1 case (0.633 per cent.).
Bacterium coli commune and Bacillus pro- digiosus.....	1 case (0.633 per cent.).
No growth.....	4 cases (2.532 per cent.).
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Total.....	158 cases (100.00 per cent.).

From the foregoing, therefore, it is evident that *Bacterium coli commune* was found alone in 72.65 per cent. of the acute cases and in 89.873 per cent. of the chronic cases; that it was found either alone or in combination with other bacteria in 117 (91.4 per cent.) of the acute cases and in 151 (96.2 per cent.) of the chronic cases. Although these facts are extremely suggestive, the relation of *Bacterium coli commune* to the development of appendicitis and consecutive peritonitis is not the simple one that it at first sight appears.

It is not many years since *Bacterium coli commune* was looked upon merely as an innocuous inhabitant of the intestine—as an organism devoid of pathogenetic properties. Its detection in pure culture, however, in many cases of peritonitis, as well as in morbid conditions of other intra-abdominal organs, directed attention to the possibility of it possessing pathogenetic attributes. Finally, the determination that *Bacterium coli commune* isolated from the intestine in case of disease of that structure is more virulent than that secured from the normal intestine, and the experimental production of peritonitis by the introduction of cultures of this organism into the peritoneal cavity of lower animals, definitely proved its pathogenetic properties.

Investigations of recent years have conclusively demonstrated not only that *Bacterium coli commune* is variable in pathogenetic properties—that is, in virulence—but also that it exhibits other biological and morphological differences, such as of size, shape, motility, etc. It suffices to mention that its variation in size is well known; that some cultures are much more actively motile than others; that Adami has recently described a diplococcus form; and that the organisms described as *Bacillus pyogenes foetidus* (Passet), *Bacillus lactis aërogenes* (Escherich), *Bacillus neapolitanus* (Emmerich), *Bacillus enteritidis* (Gärtner), the pyogenic urinary bacillus of Clado and Albarran, etc., are most likely but varieties of a class of bacteria most appropriately designated the “colon group.” These exhibit quantitative differences in their biological characteristics, but it is questionable if they do so to a degree sufficient to warrant their separation into distinct species.

When *Bacterium coli commune* was found in the peritoneal cavity, and in the exudate upon the serous coat of the intestine, in

the absence of perforation of that structure—as, for instance, in so-called idiopathic peritonitis, strangulated hernia, volvulus, etc.—the relations of this organism to the intestinal wall and *vice versa* demanded study. That which particularly required elucidation was the question whether this micro-organism possesses the power to penetrate the wall of the intestine. As a consequence of investigation it has been determined that this bacterium does possess the power to penetrate the wall of the intestine, although the normal intestine, particularly its mucous membrane, opposes effectually a barrier to the bacterium of ordinary virulence. If, however, the bowel be reduced in resistance—as occurs in congestions, inflammations, etc.—the bacterium penetrates the wall with more or less facility. It is most certain, also, that the toxin elaborated by virulent *Bacteria coli communia* retained within a restricted portion of the bowel may so alter the mucous membrane as to permit of invasion of the wall. This, without a doubt, occurs in such an anatomical tube as the appendix.

We have thus come to view *Bacterium coli commune* as a group of bacteria rather than as a single species. The individual species have been described under a variety of names, and exhibit quantitative differences in their biological properties. These bacteria are normal in all portions of the intestinal tract where they appear a few hours after birth. They are probably directly or indirectly concerned in the processes of digestion. Ordinarily, they are but slightly virulent, or they may be innocuous. Under a variety of circumstances, however, they become greatly increased in virulence, and their toxin may acquire very high potentiality. This augmentation of virulence occurs in a number of diseased states, such as obstruction, strangulation, volvulus, congestion, œdema, and inflammation of the bowel; in various diarrhœic conditions, such as that which follows the administration of purgatives, typhoid fever, cholera, etc.; and in marked and long-continued constipation. This heightened virulence may be due to the association with *Bacterium coli commune* of other bacteria, but under some circumstances it seems to be due to alterations of the bowel alone.

That *Bacterium coli commune* is not the only micro-organism concerned in the pathogenesis of appendicitis is sufficiently evident from the foregoing statistics and from the investigations of other

observers. Tavel and Lanz first directed attention to the frequent implication of several forms of bacteria in the production of appendicitis, and these authors were soon followed by Barbacci, and since then by others, among whom may be mentioned Welch and others in this country. It has been contended by these observers that appendicitis is the consequence of a mixed infection; that it rarely results from a mono-infection. The fact that *Bacterium coli commune* alone is usually isolated from cultures of the pus from cases of appendicitis is explained by stating that *Bacterium coli commune* proliferates much more luxuriantly than do the other bacteria present, and thus outgrows them.

In but 33 of the 286 cases examined was such mixed infection demonstrated by the methods of investigation pursued. These comprised 24 acute cases (18.75 per cent.) and 9 chronic cases (5.7 per cent.). It should be mentioned here that in those instances in which cover-slip preparations of the contents of the appendix and of the peri-appendicular exudate and pus were examined the results of the examination did not differ from the results obtained by culture methods. Cocci, in particular, were conspicuous by their absence. In this respect my own investigations are somewhat at variance with those of other observers. While free to admit that the systematic examination of such cover-slip preparations in all cases of appendicitis might lead to the detection of the associated presence of two or more varieties of bacteria in a larger number of cases than my statistics indicate, I am nevertheless confident that *Bacterium coli commune* takes by far the greatest part in the bacterial origin of appendicitis.

I have repeatedly observed that if the cover-slip preparations be made from the contents of the appendix at a point somewhat removed from the seat of most manifest disease, a great variety of bacteria will often be disclosed. In the same case, however, preparations from the seat of more advanced disease, or from the peritoneal exudate or pus, will disclose only a bacillus morphologically identical with *Bacterium coli commune*. In a few cases cocci also were detected, but not in a greater proportion of cases than is indicated by the statistics as previously cited. I am inclined to consider the contaminating organisms in the first-mentioned instances as more or less innocuous, non-pathogenic, intestinal bacteria.

I have also taken opportunity to examine sections from a number of acutely inflamed appendices for the presence of bacteria in the various coats of the wall of the organ. The organisms that it was possible to identify were almost exclusively such as were morphologically similar to *Bacterium coli commune*. In exceptional cases some cocci were also seen. The micro-organisms were commonly within the lymph spaces, and were often some distance in advance of the cellular alterations. Of course, I am not unmindful of the fact that such evidence with reference to the identity of bacilli must be accepted with great reservation. It is extremely suggestive, however, that cocci were so regularly conspicuous by their absence, and that *Bacterium coli commune* was equally conspicuous by its presence—not only in cover-slip preparations made from the intra-appendicular pus, extra-appendicular exudate, and pus, but also in the respective cultures and in the wall of the appendix.

Of the extreme virulence of *Bacterium coli commune* under certain conditions sufficient experimental and clinical evidence has been accumulated. When to this we add the fact that the conditions in the appendix are most favorable for the sudden and rapid increase in the virulence of a bacterium that may be innocuous, or almost so, in other portions of the intestinal tract, it seems to me that the predominating importance of this organism in the ætiology of appendicitis cannot be gainsaid. It cannot be denied that *Bacterium coli commune*, under suitable conditions, proliferates most luxuriantly in culture media. Nor, on the other hand, can it be denied that the appendix is a most appropriate test-tube, and that the contents of the appendix are most suitable media in which to cultivate a virulent growth of *Bacterium coli commune*. I believe, therefore, that as this organism outgrows other bacteria in artificial media, so also does it, under suitable conditions, assume a predominance in the appendix. This organ like the intestine, under normal circumstances contains a variety of bacteria; but under conditions favorable for the development of appendicitis, particularly when the lumen of the appendix becomes occluded, *Bacterium coli commune* rapidly becomes the predominating and most virulent organism.

These statements naturally do not eliminate from consideration other bacteria as ætiological factors in inflammatory affections of

the appendix. A number of other micro-organisms have been found sufficiently often by different observers, as well as by myself, and their virulence has been repeatedly tested, to indicate their importance in the production of appendicitis. Interest is attached to the presence of *Bacillus pyocyaneus* in six of my cases of acute appendicitis and in two of the cases of chronic appendicitis. The pathogenetic importance of the streptococcus, when present, cannot be overestimated, and the same is also true of the staphylococci. I have attempted to verify the findings of Dudgeon and Sargent, as to the uniform occurrence of staphylococcus albus in the early stages of appendicular peritonitis and my results are altogether at variance from those obtained by these observers. The recent work of Hyde on the anaerobic organisms draws attention to several interesting points in connection with this group of the intestinal flora. He claims to find anaerobes predominating in the tissues at the margin of advancing peritonitis, also he finds certain anaerobes which can cause direct necrosis with decomposition and holds this type of organism responsible for the severe, toxic, clinical picture so often seen in appendicitis. Hyde adduces experimental proof of the heightened activity of both anaerobes and aerobes under condition of symbiosis and therefore attaches clinical importance to differences in diet which would be expected to cause differences in the bacteriology of appendicitis. It is quite possible that the occasional apparent contagiousness of appendicitis, its occurrence in families, and the marked absence of it among the Chinese, may depend upon such peculiarities in diet. Of other bacteria encountered in appendicitis the following may be mentioned: Varieties of proteus, *Bacillus subtilis*, *Bacillus capsulatus*, *Coccus conglomeratus*, *Bacillus fusiformis*, bacilli resembling those of diphtheria, glanders, tetanus, actinomycosis, etc., and the pneumococcus, etc. The last-named organism was isolated by Barbacci from 60 per cent. of his cases, but I have not encountered it.

Undoubtedly, in certain cases bacteria other than *Bacterium coli commune* do contribute to cause appendicitis; in some cases they are doubtless the sole ætiological factor. This is indicated by the fact that in certain of my own cases, as well as in those of other observers, this bacterium was absent, whereas other micro-organisms were present. It has been stated that undue prominence is assumed

by *Bacterium coli commune* because of the property it possesses of invading tissues already the seat of morbid alterations inaugurated by other organisms. The latter, following invasion by *Bacterium coli commune*, are believed to assume a subsidiary rôle, and to become overshadowed by reason of the active proliferation of the invaders. Personally, I am inclined to accord predominance to that organism which, it is believed, so readily overcomes such well-known and virulent bacteria as the streptococci, etc., rather than believe that other organisms inaugurate the morbid condition in the appendix and then succumb to the activities of *Bacterium coli commune*. I believe that conditions are analogous in the appendix and in the test-tube; and that, further, as most of my examinations of acute cases were made very early in the attack, if bacteria other than *Bacterium coli commune* were so frequently concerned in the ætiology of appendicitis, as is held by some, they would have been detected by the methods of investigation pursued.

As will appear later, the most important factor in the augmentation of the virulence of *Bacterium coli commune* in the appendix is defective drainage. When the drainage of the appendix becomes impeded or ceases entirely, *Bacterium coli commune* rapidly multiplies and increases in virulence, producing a toxin of very high potentiality. This, either alone or associated with the products of decomposition of the appendicular contents, suffices to inaugurate catarrhal alterations in the appendix. As a consequence of this, and also of the mechanical pressure exerted by the accumulating secretion, the mucous membrane becomes reduced in vitality, and invasion of the wall of the organ is a matter easy of accomplishment. The bacteria may successively invade each coat of the appendix until they reach the serous coat. Here they may give rise to a peritonitis, which may become suppurative, and may be either circumscribed or diffuse. It is thus that peri-appendicular suppuration arises in the absence of perforation of the appendix. As the bacteria penetrate deeper into the wall of the appendix, they commonly liquefy the tissues by peptonizing them, and, as a matter of fact, most cases of appendicitis with appendicular peritonitis present more or less ulceration of the appendix. In some cases the toxin elaborated is excessively virulent (and some of these are doubtless streptococcic), and there is widespread disease of the

appendix, possibly gangrene, with virulent peritonitis, and still no perforation of the appendix. There thus can be no question that bacteria alone are amply capable of exciting appendicitis; that such appendicitis may be attended by ulceration in the absence of appendicular calculi; and that suppurative peritonitis may be associated with appendicitis without perforation of the appendix.

The differences in the severity of the clinical manifestations of cases of appendicitis are explicable upon the assumption of variations in the virulence of the toxins elaborated by the bacteria provocative of the inflammatory attack. In some cases it is likely that two or more varieties of bacteria acting in symbiosis produce a much more virulent composite toxin than would either alone. The leucocytes and nuclein are defenses provided by nature, but they are often ineffectual. The absorption of the toxins engenders the various general manifestations of the disease, of which the most important are albuminuria with casts; urobilinuria; indicanuria; a peculiar icteric tint of the skin; disturbances of cerebration, of cardiac action, etc. It is a peculiarity of the toxin of some cases which develop insidiously that it gives rise to symptoms which, for a time at least, much resemble those of typhoid fever.

THE PATHOGENESIS.¹

In considering the pathogenesis of appendicitis it must be borne in mind that inflammation of the vermiform appendix is in many respects so unique a disease; it differs so materially from inflammatory affections of other portions of the gastro-intestinal tract; it is often so sudden in its onset, so alarming in its aspects, and so disastrous in its consequences, that it behooves us to look for some cause or causes resident in or about the appendix itself to account for the much greater frequency of inflammation of this portion as compared with other portions of the gastro-intestinal tract, and for the preponderating rôle such inflammation plays in the ætiology of peritonitis. As a matter of fact, there pertain to the appendix certain important anatomical and physiological peculiarities that must of necessity exert considerable influence in the production of diseased

¹ Consult: Kelly, A. O. J., "The Pathogenesis of Appendicitis," Philadelphia Medical Journal, iv, pp. 928, 983, and 1032, 1899.

conditions of that organ—that act as **predisposing causes**. The most important of these are: (1) The shape of the meso-appendix; (2) the excessive length as compared with the width of the appendix; (3) Gerlach's valve; (4) the histological structure of the organ; (5) the blood supply; (6) the nerve supply; (7) the evidences of involution of the organ.

The **meso-appendix** is of importance for several reasons. It not only acts as a predisposing factor in the causation of inflammation of the appendix, but it also has important bearings with reference to the possible results of such inflammation. The relations of the appendix to the peritoneum and *vice versa* are various. As a rule, the appendix is completely enveloped by a fold of peritoneum and lies free within the peritoneal cavity—it is an intra-peritoneal organ. Exceptionally, however, its posterior surface is unprovided with a peritoneal covering. Under such circumstances the organ is in direct association with the retro-peritoneal connective tissue, and this relation is of importance as influencing the course of possible peri-appendicular suppuration. Commonly, however, as already stated, it lies free in the peritoneal cavity and is almost invariably provided with a meso-appendix. The latter is usually triangular in shape, though it varies considerably in size, in thickness, and in the extent to which it is attached to the appendix. In the majority of instances the meso-appendix extends the entire length of the appendix. Exceptionally, however, the tip of the organ may be free; and more rarely, the meso-appendix may be attached to but the proximal two-thirds or one-third of the organ. It is, however, because of its size that the meso-appendix bears an important ætiological relationship to appendicitis. If it have a breadth commensurate with its length, or if it be very short or entirely absent, as far as the meso-appendix is concerned, the appendix will be quite straight. If, however, it be relatively narrow as compared with its length, the appendix will be correspondingly curved or distorted. Under such circumstances, depending upon the degree of the curve, flexure, or distortion, the free drainage of the appendix, so essential to its well-being, is compromised. As will be detailed later, when the free and thorough drainage of the organ is interfered with, one of the most important ætiological factors of appendicitis becomes operative.

The **excessive length of the appendix** as compared with its width, and more particularly with the calibre of its lumen, is another important ætiological factor in appendicitis, and this also because of the interference thereby engendered with thorough drainage. Appendices vary considerably in length, some being very short, others very long. The longest that I have encountered was 14 cm. The average length is from 8 cm. to 9 cm. On the other hand, the diameter of the lumen of appendices that appear not to have been diseased varies between 3 mm. and 5 mm., and there are often marked differences at different levels of the same organ. The relation, then, of the diameter of the lumen to the length of the appendix is about as 1 to 16 or 25—an evident disproportion, to which must be ascribed considerable pathogenetic significance. It appears that if the appendix once becomes the seat of disease, this disproportion is much accentuated. Thus, in over 75 per cent. of appendices the seat of chronic inflammation that were examined the lumen had been reduced in diameter to 2 mm. or less throughout. In a number of the remaining 25 per cent., the lumen was but 2 mm. at certain levels, but exceeded this at others. Of those in which the diameter of the lumen was 2mm. or less throughout, it was in many places 1 mm. or less. The pathogenetic significance of this disproportion between the calibre of the lumens and the length of appendices apparently healthy becomes much augmented if for any reason the lumen be diminished, as by chronic inflammation or otherwise.

The exact significance to be attached to **Gerlach's valve** is indeterminate, and this largely because that structure itself is very indeterminate. It is usually evident, when the cæcum is viewed from within, as a small prominence of the mucous membrane surrounding, either completely or in part, the orifice of the appendix. Upon close inspection it is seen to be made up of a reduplication of the mucous membrane, and microscopical examination reveals, in addition, some lymphoid tissue. It is better developed in youth than in old age. It is said to be most marked in infants during the first year of life; in adults and the aged it often eludes detection by the unaided eye. Microscopical examination, however, usually reveals some indication of it. Krafft states that Nanninga has observed immediately below this valve a second smaller one. At all events the valve is

admittedly a rather inconstant structure. Nevertheless, it can readily be surmised that when present it serves to retard the entrance into the appendix of intestinal contents, and to hinder, possibly to a less degree, the escape into the cæcum of appendicular contents. It is this latter function that is the more important in this connection. If for any reason the region of the cæcum about the appendicular orifice, or Gerlach's valve, becomes swollen, the escape of appendicular contents is more effectually prevented, defective drainage ensues, and appendicitis results.

The **histological structure of the appendix** has important bearings upon the pathogenesis of inflammation of the organ. It is quite correct to state that in general the appendix conforms in histological architecture to the structure of the large intestine, but it is, nevertheless, very unwise to lose sight of the many particulars in which it presents deviations from that type. That which is especially the most important is the presence in the mucous membrane of the appendix of a considerable amount of lymphoid tissue. These lymphoid cells at times infiltrate without definite arrangement the mucosa; at times they are collected into definite groups that are spoken of as lymphoid follicles. It is because of this richness in lymphoid tissue that the appendix has been aptly compared to the tonsil. It has been spoken of as the "abdominal tonsil," and comparison has been made between cases of "simple tonsillitis" and "simple appendicitis" (which Sahli even speaks of as "angina of the appendix")—both of which are considered by some amenable to medicinal treatment—and between suppuration of the tonsil and suppuration or sloughing of the appendix.

The amount of lymphoid tissue in the appendix seems to bear some relation to the age of the individual, and this may not be without significance in the ætiology of inflammation of that organ. My investigations, which have been so largely with diseased appendices, hardly warrant me in formulating a positive opinion on this subject; they have, however, led me to believe, with Ribbert and Kelynack, that lymphoid elements are more abundant in the appendix during childhood than during later life.

Berry and Lack have made very full and apparently conclusive studies upon the histological structure of the appendix and especially of its lymphoid tissue. They state that its formation does not begin

until one to six weeks after birth there being practically none in the appendix of the full term foetus. At thirty-two weeks the lymphoid tissue acts as an actively functioning gland.

The lymphoid tissue seldom totally disappears but is present in great amounts in early life and shows a progressive tendency to disappear. They tabulate the average number of lymphoid follicles present in a single transverse section through the centre of the human appendix, as follows:

Below 1 year.....	5
1 to 10 years.....	6
10 to 20 years.....	7
20 to 30 years.....	6
30 to 40 years.....	3
40 to 50 years.....	3
50 to 60 years.....	2
60 to 70 years.....	trace only.
70 to 80 years.....	practically none.

Very obvious changes do not take place until the age of about thirty. Then the lymph follicles show a tendency to become flattened and diffuse while the mucosa commences to show signs of atrophy. They conclude that until the fourth decade the appendix is an actively functioning gland.

It is well known that affections of adenoid tissue are more likely to occur in the young than in the aged, and in some cases of appendicitis this fact is probably of ætiological importance—appendicitis being pre-eminently a disease of adolescence and early adult life. Ribbert states that the typical arrangement of the lymphoid elements into follicles is preserved until about the thirtieth year, when the follicles commence to undergo some atrophy and become more widely separated. Exceptionally, this physiological atrophic process may be installed as early as the twentieth year. Ribbert and Kelynack, nevertheless, state that lymphoid tissue may be found in the appendices of the aged, and my own investigations certainly confirm this view. Ribbert mentions, also, that in the rabbit, more so than in man, the appendix is characterized histologically by the presence of such an amount of lymphoid tissue as to make it resemble a single large Peyer's patch. Hawkins, on the other hand, is reservedly inclined to believe that the amount of lymphoid tissue in the appendix does not bear any direct relation-

ship to the age of the individual, but states that only the examination of a large number of normal appendices would warrant any definite statements on this subject. It is reasonable, also, to assume that those the subjects of the "lymphoid diathesis" are rather prone to appendicitis, as to affections of adenoid tissue in general, and in this connection the operations of heredity may not be without significance.

Another histological peculiarity of the appendix of considerable significance is the relatively extensive epithelial surface that it presents—extensive as compared with the size of the appendix. Under circumstances of even slight irritation or erosion it thus affords a large surface for the absorption of the noxious products of bacteria. This is further increased by the numerous crypts of Lieberkühn wherein the bacteria become lodged and continuously produce their toxins.

The **blood supply of the appendix** and the pathogenetic relationship that the blood-vessels and the arterial supply bear to inflammation of that organ have been considerably studied. It is unnecessary here to go into a detailed description of the blood supply of the appendix, but some slight reference to the blood-vessels themselves may be opportune. If I mistake not, it was Fowler and Van Cott who first directed particular attention to the important ætiological rôle of the circulatory apparatus of the appendix in inflammation of that organ. These authors believe that the appendix is peculiarly exposed to vascular and nervous, and hence to nutritional, disturbances, and base their opinion upon an examination of thirteen appendices made by Van Cott. The examination of these is said to have revealed in the vessels of the meso-appendix some form or other of obstruction to the blood current, either paravasculitis, perivasculitis, or endovasculitis; and these, it is believed, must have preceded the intense round-cell infiltration, the coagulation necrosis, the purulent foci, that they detected in the walls of the appendices. Van Cott also states that in several cases he found a distinct chronic interstitial neuritis with extensive atrophy of the nerve fibres resulting from hyperplasia of the endoneurium and perineurium. He argues from these that the real cause of the *locus minoris resistentiæ* admitting of bacterial invasion is not to be sought in a trauma of the mucosa, but in a trophic disturbance of the appen-

dix, the result of chronic vascular lesion or of chronic nerve lesion, or both; and that the ulcerative processes in the appendix, while they may be increased by bacterial invasion, may nevertheless owe their origin to these trophic conditions.

These opinions have been subjected to critical investigation and have commonly not been confirmed. In particular, Breuer, at the instigation of Nothnagel, carefully examined thirty appendices, some of which had been removed at necropsy and some at operation, among the latter there being instances of acute and chronic appendicitis. By means of carefully performed injection of the arteries, he first of all determined that the vascular supply of the appendix is not a terminal one, such as obtains in the brain, spleen, kidney, etc., but that a not inconsiderable collateral blood supply comes from the adjoining cæcal vascular area. Furthermore, it was determined that these anastomosing arterial branches course partly beneath the mucosa, partly in the muscularis, and partly directly beneath the serosa. But as the pertinent result of his investigations, Breuer was unable to detect vascular alterations of the constancy and extent described by Van Cott. In cases of chronic inflammation of the appendix the larger arteries of the meso-appendix were regularly intact, even when surrounded by hyperplastic connective tissue. Not only this, but the smaller vessels—the arteries and veins—of various regions of the wall of the appendix revealed but rarely pathological alterations. For instance, in areas in which the entire mucous membrane was converted into cicatricial connective tissue there were evident but slight thickening of the vessels, endothelial proliferation, etc.—changes that, it is asserted, are detectable in every cicatricial tissue and in instances of normal involution of the appendix. In cases of acute suppurative appendicitis the alterations of the vessels were more common, but they were limited to the acutely inflamed region and its immediate vicinity. As the result of my own investigations, I believe there can be no question that Van Cott is correct in asserting that these vascular alterations are present in some presumably normal and in some diseased appendices, but I also believe that he erroneously interprets their significance and overestimates their importance.

In a considerable number of presumably normal appendices removed at necropsy and subjected to histological investigation the thick-

ness of the vessel wall of the appendix, as well as of the meso-appendix, impressed me forcibly. In many of these the deviations from the normal were almost exclusively confined to the muscular coat. In not a few instances, however, there was a distinct proliferation of the intima. The vessel walls of the remaining appendices appeared entirely normal. Pathological alterations, particularly endothelial proliferation, were more common in the diseased appendices examined. In some of the appendices that had been the seat of recurring attacks of inflammation the thickening of the vessel walls was very apparent. In some of the acute cases the endothelial proliferation was equally conspicuous. In other appendices—those which for a shorter or longer time had been the seat of chronic inflammation, and which had more recently suffered an acute exacerbation—alterations of both the media and intima were evident. In many of the acute cases, however, the vessel walls presented no noteworthy deviations from the normal. Some interstitial connective-tissue overgrowth was also occasionally detected in and about the nerves of the meso-appendix, but by no means so regularly and constantly as indicated by Van Cott. As the result, therefore, of my own investigations considerable pathogenetic significance is ascribed to the condition of the arteries, but more to the blood supply. I believe that cases in which nerve lesions may with justice be held accountable for the development of appendicitis are quite exceptional. However, excluding instances of thrombosis and embolism of the chief appendicular vessels or their branches, and obstruction of the blood supply by means of torsions, angulations, or contracting bands of connective tissue compressing the vessels, I do not believe that ulceration of the wall of the appendix can with reason be ascribed to arterial alterations. I believe, though, that the precarious blood supply of the appendix may with justice be held at least partly accountable for the disastrous consequences to the appendix of causes therein provocative of inflammation, but which in other portions of the intestinal tract remain inoperative. I believe, also, that in case the blood supply of the appendix becomes very defective by reason of torsions, flexures, etc., conditions obtain in the appendix that render the common exciting causes of ulceration very prone to produce their deleterious effects. And, finally, I believe that many of the instances of proliferation of the endothelium of the vessels

of diseased appendices are to be interpreted as the consequence, not the cause, of the inflammation.

The **indications of involution of the appendix** demand careful consideration, and the proper interpretation of suggestive alterations is frequently a matter for judicious discrimination. Particular investigation of this question has been made by Ribbert, Zuckerkandl, and Piersol. Ribbert examined 400 appendices obtained at necropsy and determined that 99 (25 per cent.) presented evidences of retrogressive atrophic alterations without indications of previous inflammation. These alterations were, therefore, interpreted as evidences of involution. Zuckerkandl investigated 232 appendices, and detected in 55 evidences of obliteration of the lumen—therefore in 23.7 per cent. Of 100 appendices of persons over twenty years of age examined by Ribbert, 32 presented these evidences of retrogression. The obliteration of the lumen was commonly but partial; it was complete in but 3.5 per cent. In one-half of the cases the distal quarter was closed; in one-half of the remaining cases the obliteration affected between one-fourth and three-fourths of the entire length of the organ; in the remaining 9 per cent. the obliteration was but partial.

There can be no question that these evidences of retrogression are common. In the presumably normal appendices removed at necropsy that I examined they were found in almost one-fourth of the cases. They were usually confined to the tip of the organ, and to a small portion of it. Exceptionally, they implicated about one-fourth, or a little more, of the entire length of the organ. In these cases the remainder of the organ presented no recognizable histological deviations from the normal. These indications of involution were also evident in appendices manifestly the seat of inflammatory disease, and, as in the other cases, they were commonly limited to the distal end of the organ. In no case did they implicate as much as one-half of the appendix. In all these cases, however, the inflammatory character of the associated alterations was beyond question.

The exact nature of these involutionary changes is still more or less a matter of conjecture. Ribbert states that in appendices undergoing these alterations three zones can usually be recognized: (1) A central zone more or less rich in cells; (2) a zone which shows

gradual transition from the first, and which is poor in cells and made up largely of connective tissue; and (3) the muscular coat. The first or inner zone corresponds to the former mucous membrane; the second or middle, to the former submucosa. The inner zone at times reveals a small, narrow slit, indicative of the former lumen. Careful examination of this, however, will often reveal a few strands of delicate connective tissue traversing it from side to side. These are readily torn and are likely to escape detection. Ribbert believes that the symmetry of the process, its progression from the distal to the proximal end of the appendix, and the absence of irregularities, of cicatricial tissue, and of other indications of previous inflammatory conditions justify the assumption that the process is involutionary in nature. It may be mentioned that this fact is indicated, in addition, by the absence of degenerative alterations in the mucous membrane—the change being rather one of gradual atrophy. I believe, with Zuckerkandl, that the submucosa plays a most important rôle in these alterations, and that the changes in the other coats follow those of the submucosa. Piersol concurs in this opinion, stating that “changes within the submucosa inaugurate the process leading to the retrogression of the appendix and precede the alterations affecting the mucosa.” Defective nutritive supply is doubtless the basis of the process. As regards the rôle that these involutionary changes play in the causation of appendicitis, it suffices for the present to state that they are to be considered as indicative of a *locus minoris resistentiæ*, which permits of the more ready operation in the appendix than in other portions of the intestinal tract of the exciting causes of appendicitis.

Berry and Lack do not consider obliteration of the appendix a physiological process because it occurs at all periods of life and a progressive examination of appendices from birth to the most advanced age does not reveal any great increase in the tendency to obliteration. They found seven instances in 103 examinations and each was, they assert, the evidence of an interstitial fibrosis the result of vascular obstruction. Aschoff concludes also that obliteration of the appendix results from inflammation and is not a physiological procedure.

The foregoing, then, are the factors that predispose the appendix to attacks of inflammation. They acquire their pathogenetic

significance because they interfere with the proper and thorough drainage of the organ; because they reduce the capability of the organ to resist the influences of various morbid agencies; because of the facility with which nutritional disturbances may be engendered; and because of the relatively large surface presented for the absorption of the toxic products of bacteria that find their exit from the appendicular lumen retarded or prevented. Bearing in mind these facts, when we institute a study of the pathogenesis of appendicitis, it is immediately patent that no one factor alone can be held accountable for the development of all cases of the affection. On the contrary, the previously mentioned anatomical and physiological peculiarities of the appendix render the organ less resistant to the well-known morbid agencies provocative of inflammation in other portions of the body. In individual instances one or the other of these peculiarities predominates over, and thus assumes a pathogenetic significance disproportionate to, the others.

The **exciting causes of appendicitis** do not differ from those that induce inflammation in other portions of the body. As is well known, the most common causes of inflammation are mechanical and chemical irritation and bacteria. In a given case of inflammation it is often difficult to distinguish sharply between these ætiological factors, particularly between the action of chemical irritation and bacteria; in many instances there is certainly no distinction. In this respect, what is true elsewhere in the body, is true also as regards the appendix.

The bacteriology of appendicitis has already been discussed. Of the production of appendicitis by chemical irritants, apart from bacteria, we know very little. That mechanical irritants, such as traumas, act as exciting causes of appendicitis is suggested by the development of appendicitis following injuries, such as blows in the region of the appendix, sudden straining efforts, etc. These traumas may act as do traumas generally, reduce the vitality of the appendix, and permit of the more ready operation of the exciting cause of appendicitis—bacteria. The relationship of trauma to appendicitis, however, cannot be close and it seems doubtful whether it has any influence whatever except under very unusual circumstances. Byron Robinson considers that the chief exciting cause of appendicitis is the action of the right psoas muscle, and

Edebohls believes that a movable right kidney is of prime importance. He states that chronic appendicitis is present in from 80 per cent. to 90 per cent. of women with symptom-producing movable right kidney, and that chronic appendicitis is one of the chief, if not the chief symptom of movable kidney.

It is well remembered that early in the development of our knowledge concerning appendicitis the origin of the disease was commonly attributed to the presence in the appendix of various foreign bodies, such as cherry-stones, grape-seeds, seeds of various other fruits, pins, needles, hair, bits of bone, gall-stones, and the like. Of recent years, as a result of more careful investigation, it has become evident that many of the formations previously considered seeds of various fruits were in reality but faecal concretions or appendicular calculi, the misconception as to their real nature being due to the resemblance that they bore in size and shape to the different objects for which they were mistaken. Undoubtedly, foreign bodies do gain access to the appendix, and in the event of that organ subsequently becoming the seat of inflammation, it is but natural to ascribe an ætiological rôle to such foreign body.

My own investigations certainly indicate the infrequency of foreign bodies as a cause of appendicitis. In one case I found a pin and have occasionally encountered the seeds of various fruits and even small bird shot. These findings are, however, exceedingly rare in comparison with the prevalence of appendicitis and may be considered practically as fortuitous. It is interesting to recall that various enterozoa have been found in the appendix. Thus, *Oxyuris vermicularis*, *Trichocephalus dispar*, and *Ascaris lumbricoides* have been encountered. In addition, Scholler has reported a case of echinococcus of the appendix in association with echinococcus of the liver, and Birch-Hirshfeld an instance of echinococcus of the appendix alone.

While, in the light of recent experimental and other scientific research, the views formerly maintained with regard to the rôle of various foreign bodies in the production of appendicitis has largely been abandoned, the relation of what we now know to be appendicular calculi to the development of appendicitis still demands careful consideration. That calculi may be borne in the intestinal tract and in the appendix without inducing any important patho-

logical process is well established as a result of the investigations of a considerable number of observers, and is being constantly confirmed by all who have occasion to see much necropsy work. On the other hand, that calculi are associated with a considerable number of cases of appendicitis is equally well established. The statistics of various observers with regard to the frequency of appendicular calculi in appendicitis have already been cited. Of 460 of the cases examined by myself they were found in 74 (16 per cent.)—35 of a total of 208 acute cases, and 39 of a total of 252 chronic cases. The 35 instances in which they were found in cases of acute appendicitis were distributed among the different varieties of this affection as follows:

Of 7 cases of acute catarrhal appendicitis.....	None.
Of 32 cases of acute interstitial appendicitis.....	2 (6.2 per cent.).
Of 56 cases of acute ulcerative appendicitis, without perforation.....	9 (16.0 per cent.).
Of 64 cases of acute ulcerative appendicitis with perforation.....	19 (29.8 per cent.).
Of 49 cases of acute gangrenous appendicitis.....	5 (10.2 per cent.).
Of 208 cases of acute appendicitis, calculi in.....	35 (16.6 per cent.).

From these statistics it is evident that calculi are present in a considerable number of cases of acute appendicitis, and it is further plain that the more severe the inflammatory lesions, the greater the proportion of cases in which they are found. Thus, they are more common in cases of ulcerative appendicitis, especially with perforation, and in gangrenous appendicitis, than in any of the other acute varieties. There can, however, be no question that they are even more often associated with some varieties of acute appendicitis than the foregoing figures indicate. It not infrequently happens in cases of ulcerative appendicitis with perforation, and in gangrenous appendicitis, that at the time of operation or necropsy the calculus has already escaped from the lumen of the appendix and is not detected during the operative manipulations, or, being detected, is not preserved.

The relation of these calculi to appendicitis, however, is not the simple one of cause and effect, as was originally assumed. A consideration of the anatomy of the cæcum and appendix is sufficien

to indicate the impossibility of formed calculi, even of small size, gaining access to the appendix—at all events, after the first year of life. (During the last-named period the appendicular orifice is often quite patulous). This view has been confirmed, if such confirmation were necessary, by some experimental investigations. Calculi, therefore, are formed within the appendix.

The condition of the cavities of normal appendices removed at necropsy varies in different instances. It has been found entirely empty; but in most cases it is partly or completely filled with fluid or semifluid fæcal matter. It is natural to infer that such fæcal matter frequently gains access to, and is as frequently expelled from, the lumen of the appendix by the muscular contractions of the organ, which are aided by the shape, position, length, calibre of the lumen of the organ, etc. If such fæcal matter remain long in the appendix, it becomes inspissated, in consequence of the rapid absorption, by the numerous lymphatics, of its watery constituents. The longer it remains, the more inspissated it becomes. It is probably the efforts of the appendix to expel such inspissated fæcal matter and calculi that give rise to attacks of appendicular colic, the occurrence of which cannot well be doubted. Nor can it be doubted that such colicky pain occurs in the absence of calculi and fæcal matter from the appendix. The irregular peristalsis of an inflamed and ulcerated appendix is of itself sufficient to give rise to acute pain, which increases in wave-like exacerbations—the manifestations being similar to the tenesmus of a posterior urethritis or a proctitis. If the egress of fæcal matter from the appendix be hindered by inappropriate position or fixation of the organ, internal constrictions, external bands of cicatricial connective tissue, swelling of the mucous membrane or of Gerlach's valve, flexures, angulations, weakness of the muscular coats, impassiveness of the organ, or other causes, the contents become correspondingly more inspissated. From what was originally a mass of fæcal matter of greater or less size, a small, hardened, fæcal particle results. Around this as a nucleus inspissated mucus, desquamated epithelial cells, pus-corpuscles, débris, etc., are deposited, in successive concentric layers. These, collectively, result in the formation of a so-called fæcal concretion. Inasmuch, however, as only the central nucleus of this concretion consists of fæcal matter, the remainder of it being

made up of the products of inflammation, etc., the preferable designation is appendicular calculus.

Chemical investigation of these calculi shows that they are composed of phosphate, carbonate, and sulphate of calcium; phosphate of magnesium; at times cholesterin, fat, débris, etc. Interesting investigations have recently been made by Ribbert, who, in addition to confirming the older view, according to which the centre of the calculus alone is made up of fæcal matter, showed, by means of Weigert's fibrin stain, that the mucus of the outer layers of the calculus is in continuous association with that filling up the mucous glands lining the appendix. It is quite likely that fæcal matter of itself, if retained in the appendix for some time, is capable of setting up some catarrhal inflammation, and this, probably, as a consequence not only of attrition of the lining membrane, but also of increase in the virulence of the retained bacteria. This is indicated by the many instances of catarrh of the appendix found at necropsy in the absence of calculi. This catarrh of the appendix is one of the most fertile sources of appendicular calculi. Not only do the swelling and œdema thus produced retard the exit of fæcal matter from the appendix and favor its inspissation by affording opportunity for the absorption of its watery constituents, but the products of the catarrhal inflammation themselves furnish the necessary ingredients—the salts—to be deposited in layers about the nucleus of fæcal matter.

Calculi in the appendix vary in number, size, shape, and color. They may be single or multiple. Usually, there is but one; there are often two; there are rarely more than four. According to Volz, they vary in size from that of a lentil to that of a hazelnut. The largest calculi that I have encountered were from a case of gangrenous appendicitis of five days' duration, the patient being reported never to have had any previous attacks. The appendix removed at operation contained three concretions. The largest was 2 cm. in length and 1.2 cm. in diameter; the second, 2 cm. in length and 1 cm. in diameter; and the smallest, 0.8 cm. in length and 0.4 cm. in diameter. The calculi are usually elongated; though some are relatively much thicker than others. They are commonly rounded at the extremities. Sometimes, however, they are distinctly conoid or pointed, as were the two largest of those the dimen-

sions of which have just been cited. Externally, they may be smooth or rough. In color they are grayish-white, yellowish, or brownish. On section, they present a distinctly lamellated concentric structure, and are harder toward the centre than toward the periphery.

Sonnenburg, writing of the formation of such calculi, or, rather, of the deposition of successive layers about the central nucleus, asserts his belief that there must have existed a dilatation of the appendix at the site where such calculi have formed. He believes that the deposition of successive layers is impossible in case the wall of the appendix surrounds the calculus firmly as an unyielding band, and that, therefore, a certain space is essential in order that mucus and other ingredients may gain access to the faecal particle. The roundish form of the calculi is also thought to indicate that they have been subject to more or less movement. Were there not a certain free space, calculi of excessive size would certainly lead to rupture before they do. Be these suppositions as they may, calculi certainly form part of a vicious circle in appendicitis. Originally, they are hardly the cause of appendicitis; rather are they the result of inflammation of the appendix. But having resulted from an attack of appendicitis, they are an important factor in continuing the inflammation, in furnishing the necessary irritant to incite renewed attacks of acute exacerbation, and in contributing to some of the most disastrous consequences of appendicitis—perforation and consequent purulent peritonitis. Granting that the attainment of a certain size presupposes more or less of a free lumen, when that size has been reached, the constant pressure and attrition of the calculus naturally results in further inflammation, erosion, ulceration, and perforation. As already intimated, catarrhal inflammation, with hypersecretion of mucus, desquamation of epithelial cells, and purulent exudate, afford ample opportunity for the increase in size of the calculi; the inflammation renders the wall of the appendix less resistant to the operations of bacteria and to the mechanical effects of the calculi; and the implication of the muscular coats lessens or prevents peristalsis and diminishes the likelihood of the extrusion of the calculus.

Considering, now, the relative rôles played by bacteria and appendicular calculi in the causation of appendicitis, it seems to

me that it may be unhesitatingly asserted that appendicitis is, without exception, an infectious process; that the inflammations of the appendix are the results of the activities of bacteria; and that the rôle of calculi is quite subsidiary to that of bacteria. Such being the case, the queries naturally suggest themselves: Why is it that bacteria normally present in the intestinal tract are provocative of such serious pathological lesions in the appendix? and why is it that calculi innocuous, or almost so, in the intestine are associated with inflammatory affections of the appendix? The reasons for these are to be found in the anatomical and physiological peculiarities of the appendix, of which mention has already been made. These, on the one hand, decrease the capability of the organ to resist the influences of various morbid agencies, and, on the other, afford opportunities for the rapid increase in virulence of bacteria contained within the appendix. Because of the previously detailed anatomical and physiological peculiarities, morbid agencies that are readily overcome by the normal physiological activities of the intestinal tract are capable, when present in the appendix, of inducing the most deleterious consequences. And, in addition, when these morbid agencies—principally bacteria—become heightened in virulence, they effect their disastrous results much more readily. It must also be borne in mind that disease is due not alone to the virulence of the determining cause—be it bacteria, trauma, or other cause—but is dependent to a considerable degree upon the predisposition of the individual, upon the vitality, the power of resistance, not only of the part affected, but also of the general economy.

To Recapitulate: The factors that operate to render the appendix less resistant than other portions of the intestinal tract to the onslaughts of bacteria and other determining causes of appendicitis are several. Of prime importance is the precarious blood supply and the consequent anæmia of many of the appendices. The blood supply is defective not so much because of the manifest alterations frequently demonstrable in the walls of the blood-vessels of presumably normal appendices, but also because of the liability of the occurrence of partial or complete obstruction of the blood channels as a result of angulations, torsions, external constricting bands of adhesions, etc., and of infective endovasculitis secondary to primary inflammation of the appendix. Disturbances of circu-

lation, and hence of nutrition, are also produced by active, and sometimes ineffectual, peristalsis of the appendix induced by an effort to rid itself of foreign bodies, calculi, or even inspissated faecal matter. The action of such circulatory and nutritional disturbances is further evident in the intense congestion often noted distal to an appendicular calculus about which the wall of the appendix may be firmly contracted, and by the fact that, under these circumstances, when perforation occurs, the part affected is not directly over the site of the calculus, but rather distal to this—the region of the previous intense congestion. Of importance in a limited number of cases are also, doubtless, alterations in the nerves supplying the appendix; but, as already stated, it is believed that these are not of such great importance as has been suggested by Fowler and Van Cott. Finally, in this connection, not without significance are the evidences of retrogression of the appendix, indicating, as they do, defective powers of resistance. The factors that in the appendix give rise to increase in the virulence of the bacteria normally present in the intestine are primarily such as interfere with thorough drainage of the organ. Defective drainage may supervene when, for any reason, the appendix is so situated that it cannot be readily emptied; when its lumen is constricted, either externally by bands of cicatricial connective tissue (peritoneal adhesions), tumor formations, etc., or by cicatrices of its wall, or by obstructions within its lumen (as, for instance, by calculi or foreign bodies); or when the muscular coat of the organ is no longer capable of active peristalsis as is likely to be the case when the appendix is itself diseased or bound down by adhesions. Congestive disturbances of the appendix or of the cæcum may cause such swelling of the mucous membrane as to lead to approximation of the opposed surfaces in the appendix, or to occlusion of the outlet of the organ, and thus effectually prevent drainage. Of considerable significance with reference to this question of drainage are certain of the anatomical and physiological peculiarities of the organ previously described. Of these, may be mentioned the size and shape of the meso-appendix, the excessive length as compared with the calibre of the lumen of the appendix, and Gerlach's valve. As further conducive to imperfect drainage are the already mentioned torsions, angulations, peritoneal adhesions, cicatrices of the wall of

the appendix, etc., which interfere not alone with the blood supply, but also with thorough drainage. Appendicular calculi are capable of at least a two-fold action, and that within a vicious circle. Originally resulting from, rather than causing an attack of, appendicitis, they may not only occlude the lumen of the organ and prevent drainage, but they may also induce passive congestion in that portion of the appendix distal to their situation, and by attrition—the result of constant or intermittent peristalsis—cause erosions of the mucous membrane, and thus reduce the power of the organ to resist the attacks of bacteria and their toxins. When small, these calculi are often doubtless innocuous; but when they have attained a considerable size, and are no longer capable of being extruded, they may engender the most disastrous consequences. The erosion and necrosis of the mucous membrane, resulting from constant attrition, progress, affecting all the coats, until perforation may be produced. As the erosion or ulceration increases there is afforded a favorable focus for the ready invasion of bacteria and the free absorption of their toxins. Thus, while calculi are of subsidiary importance in exciting the original attack of appendicitis, it is believed that in many cases they are of very great importance in determining perforation of the appendix and the situation of the perforation. These are evident from the preponderating number of cases in which calculi are found in ulcerative appendicitis with perforation, and in the direct association of the calculus with the site of the perforation. In addition, appendicular calculi are of considerable significance in the production of chronic recurring appendicitis, in provoking the acute exacerbations in a chronically inflamed appendix.

The preponderating importance of defective drainage in the pathogenesis of appendicitis is sufficiently evident from an examination of a large number of diseased appendices, but it finds additional confirmation from the clinical and pathological observation of analogous intestinal conditions and from some experimental investigation. Increase in the virulence of bacteria, particularly of the common colon bacillus, has been found not only in the appendix when its lumen has been obstructed, but also, as already mentioned, in cases of intestinal obstruction and strangulation, in various congestive and diarrhœic conditions, and even in

some cases of marked and long-continued constipation. The experimental investigations of Roux, Roger and Josué, Dieulafoy, Frazier, and others are especially noteworthy as indicating the increase in the virulence of the common colon bacillus in the appendix when its lumen is occluded. A hollow glandular organ remains intact only as long as the production and evacuation of its secretion goes on normally. As soon as there occurs a disturbance, either overproduction or diminished evacuation, disease results. If the excretory duct of the gall-bladder be occluded, there ensues, under varying circumstances, either a hydrops, an empyema, or a cholecystitis or a cholangitis. The same is also true of the mammary gland, of the sebaceous glands of the skin, and of the appendix. When the lumen of the latter becomes obstructed, there occur retention, stagnation, and decomposition of its contents. This stagnation contributes also to the vicious circle, in that it not only exerts a deleterious influence on the wall of the appendix by reason of the mechanical pressure to which it gives rise, but it also serves as a most suitable culture medium for the growth of bacteria. When to the products of decomposition there are added the toxins produced by the retained bacteria increasing in virulence, the cause of appendicitis is self-evident.

As additional factors of importance are the relatively large extent of mucous membrane presented by the appendix and the large amount of lymphoid tissue, not only in the neighborhood of Gerlach's valve, but also scattered throughout the wall of the appendix. The latter is of especial significance in view of the proneness of adenoid tissue throughout the body to inflammation whenever subject to even slight irritation by bacteria and their toxins. The mucous membrane, particularly if it be eroded or ulcerated, presents a very large surface for the ready invasion of bacteria and for the absorption of their toxins. This latter is of especial importance in the production of gangrene of the appendix—the result often of infective thrombosis or embolism following erosion or ulceration of the wall of the appendix.

It must also be remembered that the appendix is prone to participate in severe intestinal lesions, particularly those of typhoid fever and dysentery; and while the latter may subside without the production of appendicitis, there frequently persist sequels, in the

form of cicatrices, etc., that are not without significance in the causation subsequently of inflammation of the appendix. Further, Klecki and other investigators have shown that *Bacterium coli commune* differs in virulence in various portions of the intestinal tract. It is most virulent in the ileum, less so in the jejunum, and least virulent in the duodenum and colon. It is conceivable that the attacks of indigestion accompanied by diarrhœa that in many instances precede the outbreak of appendicitis may result in the conveyance to the appendix of virulent bacteria, and that these overcome the resistance of the appendix more readily than do the less virulent bacteria normally present in the appendiculo-cæcal region. On the other hand, increase in the virulence of *Bacterium coli commune* has been found in the cases of marked constipation which, as is well known, sometimes precede the development of appendicitis.

From the foregoing, therefore, it is evident that no one factor alone can be held answerable for the production of all cases of appendicitis. Although the affection is without exception the consequence of micro-organismal infection, it is of rather complex pathogenesis, and no one morbid agent is provocative of all attacks. It is because of the anatomical and physiological peculiarities of the appendix that factors innocuous in the intestine, or morbid agents capable of being successfully combated by the physiological activities of the intestine, become, in the appendix, of heightened virulence and, meeting lessened resistance, engender the most disastrous consequences. Finally, it is interesting to mention that Goluboff regards appendicitis as an infectious disease *sui generis*, as are follicular tonsillitis, dysentery, etc., and that he expresses the opinion that, in addition to the occurrence of sporadic cases, the affection may develop epidemically—that it is then an epidemic infectious disease. But this view can hardly be maintained with reason.

SYMPTOMATOLOGY.

In considering the symptomatology of acute appendicitis it must be borne in mind that it is not always possible to determine the pathological alterations in the appendix from the clinical manifestations of the disease. It is futile to ascribe to any symptom or symptom-complex pathognomonic significance with regard either to the progress or to the stage of the affection. It is true that there is a symptom-complex which, when present, warrants us in assuming the existence of mild appendicitis, or in assuming that the inflammation is confined to the appendix; that there is another symptom-complex that suggests appendicitis with circumscribed peri-appendicular suppuration; and that there is still another symptom-complex indicative of appendicitis with diffuse peritonitis. Such, however, are the manifold differences in the clinical manifestations of similar anatomical lesions of the appendix that the establishment of symptom-complexes that shall indicate definite pathological lesions of the appendix is impossible. There can be no question that reliance upon such symptom-complexes as have been formulated frequently leads to egregious diagnostic blunders. While it is true that, in general, the clinical manifestations become more marked with increase in the severity of the appendicular and peritoneal lesions—that is, when perforation, pus formation, or gangrene supervene—it is also a fact that remission of all symptoms, except local tenderness, may occur, and yet the disease may be progressing to a fatal termination. It is likewise a fact that the symptoms suggestive of perforation of the appendix and peri-appendicular suppuration in one patient may arise in another patient in consequence of the development of peri-appendicular suppuration without perforation of the organ. It thus seems rational not to attempt to separate clinically cases of appendicitis in groups—such as mild or non-perforative, gangrenous, etc.—but to describe acute appendicitis as a clinical entity whose manifestations seem more dependent upon the virulence of the infection and the resistance of the individual than upon the character of the lesions of the appen-

dix and the surrounding peritoneum. Similar reasoning obtains with regard to chronic appendicitis, although in the latter the questions requiring solution are less complicated. In the vast majority of cases of chronic appendicitis the entire organ is affected, and such can be assumed with justice in the presence of the appropriate clinical symptoms. The supposition that merely catarrhal alterations exist may seem warranted in some cases, but examination of the excised appendix will usually reveal pathological lesions of all the coats. It need scarcely be mentioned that obliterative appendicitis cannot be recognized clinically.

The symptomatology of two forms of appendicitis—the acute and the chronic—will be described. The acute form embraces those varieties of inflammation of the appendix usually described clinically as simple catarrhal, ulcerative, perforative, fulminating or gangrenous and which, upon examination of the excised appendix, reveal acute catarrhal or interstitial inflammatory alterations, ulceration with or without perforation, or partial or complete gangrene. These terms represent in great part only differences in the degree and extent of the local inflammatory phenomena—differences between which it is impossible in all instances clinically to draw a distinction. The chronic form of appendicitis includes those varieties described clinically as subacute, chronic, relapsing, and recurrent, and which, upon examination of the extirpated appendix, reveal chronic catarrhal and interstitial inflammatory alterations, with or without ulceration, progressing in some instances to obliteration of the lumen of the organ—obliterative appendicitis.

ACUTE APPENDICITIS.

There are three symptoms of acute appendicitis so constant, and when associated, so characteristic of the affection that I have designated them as the “three cardinal symptoms.” These are pain, tenderness and rigidity of the right lower quadrant of the abdominal wall.

Pain is the initial symptom in all cases. It usually develops suddenly *in one previously well*, continues a variable length of time, recurs at irregular intervals, and is distinctly cramp-like or colicky in character. It has frequently been observed that the ingestion of

food, especially when indigestible or improperly cooked, has been followed shortly by the onset of the attack. More often however there is no apparent relation to the taking of food.

The paroxysmal character of the initial pain cannot be insisted upon too strongly. It is sometimes spoken of as appendicular colic, but the term seems objectionable because in its general acceptance it relegates the rôle of inflammation to a position subordinate to the mechanical factors of spasm, tension and distention. Doubtless there are cases of non-inflammatory colic due to the efforts of the appendix to rid itself of retained mucus, faecal material, concretions or foreign bodies. Such simple colicky attacks are, however, negligible in number when compared to the usual case in which the painful paroxysms are due to the inflamed state of the organ, being elicited by any movement, whether active, such as intrinsic peristalsis, or passive. In most instances both inflammation and mechanical factors are instrumental in producing the pain and each if originally present alone, predisposes strongly to the other. It is quite impossible to distinguish clinically between the two types of pain since they differ in no way. The use of the term appendiceal colic therefore implies a knowledge that no one ever possesses from clinical observation alone and any painful appendix is to be regarded as an inflamed appendix.

In general it may be said that the intensity of the pain bears a direct relation to the severity of the inflammatory process, yet such are the individual variations in sensibility to pain and its dependence upon the anatomical relations of the appendix that any effort to gauge the extent of the lesion minutely by a consideration of the pain alone is sure to meet with failure.

The pain continues of a colicky character for a greater or less period of time, when the paroxysms gradually lessen in number and severity. It does however persist, being continuous and of moderate severity, though acute exacerbations may from time to time occur. They may come on apparently spontaneously, but are likely to be excited by a number of causes. The passage of flatus through the ileo-cæcal valve is the chief of these, but palpation or any movement of the psoas muscle by motion of the right thigh or disturbance of the abdominal muscles by coughing, sneezing, etc., act in the same manner. I have found the pain which is brought

out by deep breathing or coughing of considerable assistance in the diagnosis. Later on in the course of the attack the pain may moderate considerably and this may be an evidence of the subsidence of the attack. Frequently, however, it is but an indication of perforation or gangrene. Particularly is the sudden cessation of previously severe pain a bad rather than a good omen as it often indicates the presence of a rapid gangrene of the appendix.

In some exceptional cases the pain is non-paroxysmal, constant and dull from the very onset of the attack. This is especially likely to be the case in recurring attacks, when the pain is often described as of a peculiar boring character. It may indeed come on very insidiously, beginning as a dull ache and gradually reaching a maximum and then subsiding. Such an onset of an acute appendicitis is particularly liable to occur in older subjects and especially the aged, and is most dangerous because the apparent mildness of the onset lulls us into a false security.

The initial pain is in the majority of cases referred to the umbilical region, next in order of frequency, to the epigastrium, and least commonly to the right iliac fossa. The typical pain of an attack of acute appendicitis is that which develops suddenly in one previously well, is cramp-like in character, referred to the umbilical or epigastric regions and later becomes localized in the right iliac fossa. The pain of appendicitis may, however, be referred to any region of the abdomen, largely depending on the position of the appendix. Lack of knowledge of this fact has led to many errors in the diagnosis of acute abdominal affections.

Rarely, we meet with a case of acute appendicitis of a mild nature in which no history of subjective pain is obtainable and I have observed this in young people and particularly in children. At times such an attack is unassociated even with tenderness and when this is so, a diagnosis except upon the basis of a previous history is impossible.

The *secondary* pain in an attack of acute appendicitis is that which results from the peri-appendicular involvement. Its location therefore depends almost entirely upon that of the appendix and the extent of the involvement beyond it. After the development of a circumscribed peritonitis the pain is usually referred to the right iliac fossa, because the appendix commonly occupies this region of

the body. If the appendix be long and overhangs the brim of the true pelvis the pain may be referred to the left side of the abdomen, or pelvis, to the region of the ovary in the female, or along the course of the spermatic cord toward the testicle in the male. If the appendix is post-cæcal with a diseased tip and points upward the pain may be referred to the loin or back or to the region of the kidney or liver. When the appendix rests upon the psoas muscle and is in relation with the anterior crural nerve, the pain may be referred to the thigh along this nerve, and even to the knee. In other cases the pain may be referred along the inguinal branch of the ilio-inguinal nerve to the inguinal canal, or to the area of distribution of the right genito-crural nerve, the testicle or vulva, or the upper anterior and inner part of the thigh. When the pain is referred to the right testicle there may occur retraction of the organ such as in renal colic. If the tip of the organ occupy the left iliac fossa or the entire appendix is situated there the pain will also be referred to this region. Such a left-sided pain is, however, not unknown in cases in which operation discloses no abnormality in the position of the organ and a diagnosis under these circumstances may be extremely difficult. I have in mind a case of appendicitis with pain at all times left sided which escaped recognition for three weeks. A pelvic and left-sided pus collection then rendering operative interference imperative, the true origin of the disease was discovered, the appendix not being abnormally situated.

Tenderness on pressure is one of the most valuable signs of acute appendicitis. This tenderness is both superficial and deep and may be elicited directly or indirectly.

The deep tenderness, caused by the intra- or peri-appendicular inflammation itself is by far the more reliable and important of the two. The area of tenderness at the beginning of an acute attack is small and is limited to the site and position of the appendix. This is usually at McBurney's point, which is located between an inch and a half and two inches from the anterior superior spine of the right ileum on a line drawn from the anterior superior spine to the umbilicus and marks for all practical purposes the position of the *base* of the appendix. Or the tenderness may be most marked at Clado's point, where the *interspinous* line crosses the right semilunar line. It is natural to expect that the tenderness should be over the seat of

the most marked disease of the appendix. As a consequence the most tender point varies more or less with the position of the appendix, and if the appendix be post-cæcal with marked rigidity of the abdominal walls, tenderness may be difficult to elicit anteriorly. When the appendix projects into the pelvis tenderness may not be detected except by rectal or vaginal examination; but in women the possibility of ovarian inflammation giving a similar tenderness must be borne in mind.

While, as has been stated, the point of greatest tenderness is usually over the inflamed appendix, there are occasional exceptions to this rule. Thus, in a young adult I found the point of greatest tenderness to the left of the left rectus muscle, a little above the anterior superior spine of the ileum. By rectal examination a small and very sensitive mass was detected in the recto-vesical fossa and operation showed that the appendix occupied the latter position.

After the extension of the inflammation beyond the appendix there is a corresponding extension in the area of deep tenderness. This as a rule corresponds to the extent of the spread of the inflammatory process. The tenderness is greater over a forming abscess or over the area of a diffusing peritonitis than over an abscess already formed, though even in the latter it may remain exquisite until relief is obtained. I have, however, observed many cases of appendiceal abscess in which the inflammatory mass was not markedly sensitive to pressure.

General, diffuse or diffusing peritonitis is characterized by extreme general abdominal tenderness.

Deep tenderness may at times be elicited indirectly by the method of Rovsing. He has shown that pressure over the descending colon at a point corresponding to McBurney's point on the right side will give pain in the region of the diseased appendix. Especially is this noted when the palpating hand is carried upward along the descending colon. This referred tenderness is caused by forcing the gas contained in the colon around toward the ileo-cæcal region and is in every way similar to that obtained by direct pressure. I have not found it a symptom of value.

The gradual amelioration of tenderness over a diseased appendix in most instances signifies a retrogression of the disease process. It may remain, however, as vague tenderness in the right iliac fossa

long after all symptoms have disappeared, and indeed may never be absent entirely between acute attacks. The sudden subsidence of tenderness has an exactly opposite significance. It is usually an evidence of gangrene of the appendix. This sudden, and at times entire cessation in tenderness, particularly in a case with a sudden and abrupt onset and especially when accompanied by a complete remission of pain is always a grave sign. This is perhaps the most deceptive stage of an acute appendicitis, for whereas the patient's feeling of well-being and relief from distress would lead us to believe that he is better, in reality he is but entering the most dangerous stage of his illness.

Superficial tenderness, also described as cutaneous hyperæsthesia, is due to reflex stimulation of sensory nerves connected with the same region of the spinal cord as are the nerves supplying the appendix. This symptom has been especially studied by Head and Sherren and a late article by Bennet has again drawn attention to its importance. It is best detected by very gentle stroking or pinching motions, commencing in an unaffected part of the abdomen, and gradually approaching the sensitive area, which may be thus quite accurately defined. It occupies an area variously shaped but always is at least approximately centered by the location of the appendix. This superficial tenderness is quite constant and its sudden or gradual disappearance has the same significance as a corresponding change in the deep tenderness. Its diagnostic value is somewhat lessened by its occurrence in other abdominal conditions. Thus Rolleston observed it in a case where operation disclosed a normal appendix, but the presence of an inflamed and softening gland near the cæcum.

Rigidity of the abdominal muscles, next to pain and tenderness, is the most reliable sign of appendicitis. In the more severe type of cases and when the initial general, epigastric or umbilical pain is marked there will be rigidity of the entire abdomen, but this rigidity appears to be under the control of the patient to a great extent. As the pain becomes localized to the right iliac fossa the abdominal muscles on the right side present a constant, often board-like, resistance to the palpating hand. The rigidity varies in degree in different cases, but is generally well marked, and is most intense over the site of the inflamed appendix. In some instances the rigid-

ity is so pronounced that it precludes palpation of either the appendix or a possible peri-appendicular abscess, and, in addition, gives to the percussion note a high pitch. When the pain has been referred to the left side, if suppuration supervenes, and the pus collection occupies the pelvis, marked bilateral rigidity of the recti muscles and of the lower portion of the abdominal wall develops. When peritonitis becomes diffuse, rigidity of the entire abdominal wall occurs.

Although the three cardinal symptoms are the most important indications of the presence of acute appendicitis, there are other clinical manifestations that present themselves with more or less regularity, and are of value in the diagnosis. We may divide them into two general classes.

Reflex symptoms, of which the most important are disturbances of the gastro-intestinal tract and the bladder function, and the symptoms of infection, of which we may mention fever, disturbances of the cardiac and respiratory rhythm, change in the number and character of the leukocytes, icterus and interference with the function of the kidneys.

Nausea and vomiting are observed almost constantly. The latter occurs after the onset of the initial pain and may occur but once. The initial vomiting is either the result of the abdominal pain or is a reflex occurrence. But as Ochsner points out, its continuation is due to the interference with the passage of gas and feces through the congested and partially obstructed ileo-cæcal valve and subsequent interference with the digestion of food and consequent return peristalsis into the stomach. The vomiting usually subsides with the localization of the pain in the right iliac fossa, unless it is continued by the ingestion of food or drugs. The vomited matter consists first of the gastric contents, then of bile or bile-stained fluid (the duodenal contents) and finally, if septic peritonitis supervenes, of stercoraceous material. Hiccough is sometimes observed, especially if the appendix point upward and peritonitis has developed; more particularly, however, if the diaphragmatic peritoneum is involved.

Constipation is the rule in the majority of cases. Diarrhœa is sometimes present at the outset and is usually associated with intense pain and a less favorable prognosis. In 606 of my own cases

constipation was observed in 411, diarrhœa in 78, alternate constipation and diarrhœa in 11, and in 106 the bowels were normal.

Formerly much stress was laid on the rôle of constipation as a causative factor, but, as I have already mentioned, this is unimportant. As a symptom, it is due to reflex paralysis of the bowel often associated with an intestinal paresis the result of infection or of the excessive use of opium or morphine. Under any of these conditions the constipation may be so severe as to simulate intestinal obstruction. It may, however, not develop at the onset of the attack, but its definite occurrence may be postponed until the third, fourth or fifth day, after which it may be most marked.

Bladder symptoms may also be present, due to disturbance of the sympathetic nervous system or to propagated inflammation of the bladder itself. They may be manifested in *frequency of urination* with pain, burning or urgency, or in a more or less marked retention. The latter and also the more severe and long-continued examples of frequency of urination are more often due either to the proximity of a pelvic appendix to the bladder serosa or the direct irritation thereof by pelvic exudate or pus. Two years ago I had occasion to observe a case of this nature. The patient had had an attack of appendicitis a week previously, but thought he had recovered. He came under my care at the German Hospital for retention of urine and examination disclosed its cause in a purulent pelvic peritonitis of appendiceal origin.

The temperature varies greatly in different cases of the same nature and in general is a most unreliable factor in both diagnosis and prognosis. "A very high temperature usually means a grave condition, but a low temperature does not ensure the slightest degree of safety" (Ochsner). In what may be termed a typical attack of appendicitis there is usually moderate fever. That is, at the commencement of the attack there is generally fever that amounts to 101° to 103° F. or more. The temperature usually rises rapidly, but sometimes rather slowly, and remains at about 101° F. for one, two or three days, after which it gradually returns to normal. Subsequent elevations of temperature are possibly associated with new foci of infection or of absorption of toxins. The approach of the temperature to the normal may continue in spite of the development of severe complications. The sudden fall of the temperature to

the normal or subnormal must not be looked upon as a favorable sign. It is very often a sign of the rapid progress of gangrene or the rupture of an appendix or peri-appendicular abscess. When following gangrene or perforation of the appendix a peri-appendicular abscess forms, there is usually a rise in temperature, up to 104° or 105° F. which may betoken the existence of some complication due to spreading infection or sepsis, such as septic phlebitis or abscess of the liver. Under these circumstances it soon becomes fluctuating, irregular and associated with other unmistakable signs of sepsis. Hyperpyrexia of marked degree occurring as an initial symptom in appendicitis and continuing unabated is a most grave sign. It occurs in severe and fulminating cases, particularly of the streptococcic variety (Hann) and renders the prognosis bad.

The pulse rate is of just as little diagnostic value as the temperature. As a general rule it may be stated that a fluctuation in one is usually associated with a similar one in the other. The character of the pulse, however, is of considerable value with reference to the gravity of the attack and the prognosis. If the pulse be strong, of good volume, regular and the rate proportionate to the temperature, the outlook is favorable. Reversed conditions have the opposite meaning. Just as low temperature is often deceptive so also is bradycardia. Indeed Kahn has asserted that a very slow pulse in appendicitis is almost always a sign of gangrene. This statement is almost too strong, yet many cases occur in which the association of the two conditions is noted. A sudden change for the worse in the pulse alters our prognosis, but often comes too late to be of value in altering the treatment.

Chills are among the rarer manifestations of general infection in appendicitis. Their occurrence at the onset of the attack, particularly when accompanied by an initial high temperature is almost pathognomonic of gangrene of the appendix. Later in the course of the disease they may indicate some complication of a septic nature, but care must be taken to differentiate them from the purely neurotic manifestations in some patients. The development of peri-appendicular abscess is not accompanied by chills.

Icterus either before or after operation, when not directly due to a liver complication is a manifestation of severe and general toxæmia. According to Reichel, who has exhaustively studied

the subject, it is a sign of the gravest importance. In my own experience I have but rarely noted it, except in hepatic infections.

Respiration may be affected in appendicitis either because of a voluntary inaction of the abdominal muscles or by the presence of marked tympanites or general peritonitis, in which we find the breathing almost entirely costal. Occurring independently of local conditions rapid breathing is a sign of toxæmia or of some embolic pulmonary condition. In children particularly it may at times render difficult the differentiation between an acute abdominal and an acute intra-thoracic lesion.

Changes in the urine in acute appendicitis are manifestations of the general febrile state and of the action upon the kidneys of the toxins generated, and also may in part be due to the fever. The urine is usually diminished in amount, of high specific gravity, dark in color and often contains albumin, casts and increased amount of urobilin and indican. We really have an acute or subacute toxic nephritis, which may at times be very severe. Thus, Hildebrandt reports a case of appendicitis complicated by such severe renal hæmorrhagic nephritis as to obscure the diagnosis. I have records of numerous cases in which the urine was less than normal, and contained erythrocytes, hyaline, granular and epithelial casts, desquamated epithelium, granular débris, etc. In most of these cases the urine returned to normal during the convalescence, and this may be expected in favorable cases.

Leucocytosis is present in the majority of cases of appendicitis, and may be classed as a manifestation of infection. Its value as regards diagnosis, prognosis, and indication for operation is discussed in another chapter.

The **general condition** of the patient varies in different instances. In the early hours of the attack there is a general facial expression of pain and considerable anxiety. Later, with the moderation of the pain, the patient remains quiet in bed and favors the right side. A characteristic posture is usually assumed in that the patient prefers the dorsal decubitus, inclines the body somewhat to the right, flexes the right thigh, keeps the left thigh extended, demands perfect quiet, and resents disturbance in the desire not to provoke or to intensify the pain. Aside from the general expression of pain and anxiety in the early hours of the attack, the facial

expression is seldom indicative of serious disease. As the lesions become more widespread and peri-appendicular abscess or general peritonitis develop, the expression becomes more anxious, and a peculiar serious cast of countenance supervenes—*facies abdominalis*. In severe cases of sepsis cyanosis and profuse perspiration sometimes occur. When the disease is advanced, restlessness may develop. This, if marked, particularly in children, is indicative of severe infection, and of the probable presence of pus, and is a very unfavorable symptom. The tongue is usually furred; if diffuse peritonitis occur, the tongue may become dry, and sordes may collect upon the gums and teeth. In severe cases the tongue may become fissured.

The subjective symptoms must be supplemented, in making a diagnosis, by a thorough physical examination of the patient.

Inspection of the abdomen may reveal more or less *bulging* of the right iliac fossa. In the early stages of the attack this is uncommon; in the later stages it may be due to peri-appendicular abscess, to muscular rigidity or to a tympanitic distention of adherent intestines. It is rarely due to a non-suppurative inflammatory exudate and serous infiltration of the abdominal wall.

A general distention of the abdomen is not infrequently observed and in the early stages of the disease is usually due to the paralysis of the intestine because of infection, obstinate constipation with resultant accumulation of gases, or the excessive use of opium. In a few cases there develops on the first day of the attack, a general distention and some diffuse tenderness of the abdomen, usually subsiding rapidly. Richardson points out that it is possible, by means of auscultation, to distinguish between the distention due to accumulated gas and that due to paralysis of the intestine the consequence of infection; the sounds of the peristaltic action of the bowel are clearly audible in the former condition, but are absent in the latter. Distention, though usually general, may sometimes be limited to the right side of the abdomen, as a result of that portion of the bowel contiguous to the inflamed area alone being affected. This local distention may, upon occasion, become marked, by reason of the still functioning intestine forcing a greater or less quantity of gas into the affected portion. As is to be expected the distention is most marked when the peritonitis is

diffuse. In some cases of diffuse peritonitis, however, though the intestines are more or less distended, the abdomen may be quite flat and its wall rigid and hard. Under such circumstances there often arise most unpleasant symptoms the consequence of pressure from below upward upon the thoracic organs.

By **palpation**, in the early stages of an acute attack, we are usually unable to detect more than *tenderness* in the right iliac region with *rigidity*—of which mention has already been made when discussing the three cardinal symptoms of the disease. In some cases, however, we can recognize by rather deep palpation a sense of resistance, which is sometimes distinctly circumscribed, and of elongated, cylindrical outline. This may with reason be ascribed to a thickened appendix, a fold of omentum, band-like contraction of the rectus muscle, or some possible peri-appendicular exudate of a non-suppurative nature. In some cases such is the tenderness over the region of the appendix that even moderately deep palpation is impossible. In other cases the rigidity of the abdominal wall precludes satisfactory palpation.

On the other hand, in addition to tenderness and rigidity of the abdominal muscles, palpation may reveal a rather diffuse resistance or a more or less distinctly circumscribed *swelling* or *tumor* in the right iliac region. The tumor, when palpable, is of smooth or roundish contour, and its edges are usually sloping. It varies in size in different cases. It is sometimes no larger than an egg; it is usually as large as a lemon or a small orange; it is rarely as large as a cocoanut. It generally courses parallel with Poupart's ligament and is removed a short distance from the crest of the ilium. When large, however, it may reach the ilium, and may extend upward beyond its crest and beyond the median line of the abdomen. The tumor in the vast majority of cases is immobile. It is generally firm, but may be quite soft; in some cases, particularly if it be large, it may present distinct fluctuation.

The conditions upon which this tumor or swelling depends vary somewhat in different instances. In cases unattended by peri-appendicular suppuration it is due to the thickening and œdema of the inflamed tissues—the appendix itself, possibly the cæcum and particularly the omentum; to peri-appendicular serous, sero-fibrinous, and fibrinous exudate; to inflammatory alterations

not only of the viscera, but also of the parietal peritoneum of the iliac fossa and the abdominal wall; and in some cases to serous and cellular infiltration of the transversalis fascia and the abdominal muscles. In the majority of these cases the size of the swelling is dependent upon the amount of the peri-appendicular exudate, which at times is excessive. In endeavoring to formulate an opinion as to the cause of a swelling in an individual case it must be borne in mind that the plastic exudate surrounding an inflamed appendix may be 3 cm., 4 cm., or 5 cm. in thickness. As a consequence, it must not be assumed that all tumors, even if they be of moderate size, have within them a purulent focus. Some even very large swellings develop with such rapidity and become so quickly dissipated that it is impossible to hold with reason that they have been suppurative. Such exudates, however, are very prone to become purulent, and it is true that all tumors of moderate and large size are, in part at least, composed of pus. It is, of course, in cases in which there is a considerable quantity of pus that fluctuation may be elicited. I have observed several cases in which a tumor mass has been simulated by excessive muscular rigidity of the lower part of the right rectus.

Berardinone has noticed in a number of cases the sudden enlargement of a single lymph node near the external abdominal ring on the right side, above Poupart's ligament. This has not occurred in the vast majority of my cases and I consider it insignificant as a symptom of appendicitis.

Percussion is of subordinate importance in the diagnosis. In the event of a swelling or tumor forming in the right iliac fossa the note is generally dull and high in pitch. Such note may, however, be due to causes other than appendicitis with peri-appendicular peritonitis, and these morbid conditions may develop without the occurrence of dullness on percussion. Even large peri-appendicular abscesses may exist with a tympanitic note in the right iliac fossa, particularly if gas has been generated within the abscess cavity. Such note will occur, for instance, if a coil of intestine overlies the abscess. A dull note, of tympanitic quality and high in pitch, may occur in the absence of an abscess if there be excessive rigidity of the abdominal wall. At times there is found an area of tympany intervening between the ilium and the area of dullness. This is

generally due to the presence in this region of the cæcum—the abscess being situated toward the median line. Mangoldt has described the occurrence in cases of retro-cæcal abscess when this pushes the cæcum and ileum against the anterior abdominal wall of a peculiar percussion note at the outer edge of the right rectus muscle over the cæcum. He describes it as a cracked pot sound or “bruit de pot fêlé” and ascribes it to the disturbance of the fluid contents of the cæcum.

Auscultation reveals little of importance in the diagnosis. Reference has already been made to its value in distinguishing between distention due to accumulated intestinal gas and that due to paralysis of the intestine the consequence of infection. Manna-berg and Nothnagel have drawn attention to an accentuation of the second pulmonic sound of the heart in appendicitis, but do not explain the cause of the phenomenon. Accentuation of the second pulmonary sound has been observed in biliary colic and is explained on the hypothesis that there is reflex constriction of the pulmonary arteries. Auscultatory percussion by means of the stethoscope or phonendoscope may assist in outlining the tumor.

Leucocytosis has been observed in a number of cases of appendicitis. Its value as regards diagnosis, prognosis, and indication for operation are discussed in another chapter.

CHRONIC APPENDICITIS.

Chronic appendicitis is probably the most common of all abdominal diseases. Pathologic examination demonstrates that it is rare for an adult to possess an appendix that is normal in every respect.

Of 500 appendices removed as an incidental procedure during the course of abdominal or pelvic operations 317 or 63.4 per cent. showed chronic catarrhal or interstitial lesions and 71 or 14.2 per cent. were completely obliterated. There can be no question that such lesions are the result of previous acute or subacute attacks of inflammation or of mild irritative influences acting for a longer period. In general it may be stated that the appendix when once attacked by inflammation becomes more and more susceptible. When complete obliteration of the lumen finally occurs, however, the susceptibility to disease diminishes so markedly as to constitute,

for all practical purposes, a cure. If the obliterating process involves only a small segment of the appendix, in other words if a stricture is formed and especially if that stricture be near the proximal end, we have a mechanism for the retention of fæcal material and the products of secretion and desquamation that gives rise to more or less constant trouble and renders the danger of an acute attack ever present. Adhesions and kinks tend to excite congestion and inflammation of the appendix. Thickening and distortion of its walls interfere with its peristalsis, cause stagnation and predispose to renewed infection. Fæcal concretions and calculi are a constant source of irritation, often resulting in chronic ulceration of the mucous membrane and more or less marked interstitial inflammation.

The pathologic changes at the bottom of the symptoms of chronic appendicitis are legion and the symptomatology is correspondingly varied. At the present time we are not able to correlate any special combination of chronic symptoms with definite pathologic lesions with sufficient constancy to enable us to surmise before operation the precise pathologic lesion of the appendix. It is agreed practically by all, however, that the existence of symptoms referable to the appendix is sufficient indication for operation. Could the diagnosis of chronic appendicitis be made more often and operation performed during that stage the mortality of the acute disease would be reduced, since the evidence of pathologic examinations and of careful histories in acute appendicitis tend to show that in the great majority of cases the acute process is implanted upon a chronic stage of the disease.

Clinically chronic appendicitis may be classed broadly in three divisions, **relapsing appendicitis**, **recurring appendicitis** and **chronic appendicitis with referred symptoms**.

Relapsing appendicitis is one in which an appendicular inflammation is always présent but only shows itself as an acute lesion after certain intervals of comparative quiescence. The diagnosis of relapsing appendicitis is not usually difficult. We have a history of one or more acute attacks, with continued tenderness over the appendix and perhaps some of those digestive disturbances later to be discussed in a consideration of simple chronic appendicitis. The history of acute attacks alone, if they be properly diagnosed by the medical attendant is sufficient to establish the diagnosis regardless

of any physical evidences of a definite appendiceal lesion, but does not establish firmly the diagnosis of the appendicitis as relapsing instead of recurrent. This, however, is not important as regards the line of treatment to be adopted.

A **recurrent appendicitis** is one in which the acute attacks are said to be separated by periods of perfect health. I am very doubtful whether an acute or even a subacute attack of appendicitis ever runs its course to recovery leaving a perfectly healthy appendix, pathologically considered. I believe also that it is most likely that more cases are relapsing than recurring—that is to say, that in many instances where the quiescent appendicitis does not give symptoms directly referred to the appendix there are nevertheless other portions of the alimentary tract affected by it and causing symptoms referred to them individually. That recurrences are very frequent is indicated by various statistics. Thus Nothnagel gives the percentage of recurrences in his experience as 16 per cent.; Rotter as 21 per cent.; Sonnenburg as 32 per cent.; and Sahli, from a collective investigation of 4593 cases from private practice, as 20.8 per cent. Of 460 of my own cases, recurrences were noted in 312 (67.8 per cent.). The vast majority of recurrences develop within the first six months; there are less within the succeeding six months. During the following years the likelihood of recurrence becomes gradually less; recurrence may nevertheless occur after a great number of years. The number of recurrences that a patient may suffer is variable. Of the 312 patients previously referred to, 89 had two attacks, 52 had three attacks, 30 had four attacks, 18 had five attacks, 16 had six attacks, 6 had seven attacks, 2 had eight attacks, 2 had nine attacks, 4 had ten attacks, 1 had twelve attacks, 2 had sixteen attacks, 2 had twenty attacks. The number of attacks that the remainder had is not known.

The diagnosis of chronic appendicitis is usually clear to those who are in a position to see large numbers of these cases but often it proves to be a stumbling block to the practitioner whose experience is necessarily limited to the confines of his practice. If he will remember that at least nine-tenths of all symptoms referable to the right iliac fossa are due to disease of the appendix fewer cases will be overlooked. The plainer cases give a history of more or less constant distress or pain referred to the region of the appendix

and examination reveals definite soreness on deep palpation over the organ. Even in the absence of any history of acute attacks a diagnosis may be made with almost invariable accuracy on this combination alone. The type and severity of the pain may be exceedingly variable. It may be sharp and stabbing, dull and aching, burning, colicky, constant, remittent, intermittent or practically constant. It may or may not excite nausea. Intestinal flatulence is a common symptom. Slight stiffening of the overlying muscles as determined by light careful palpation is a valuable confirmatory sign. Occasionally a thickened or distended appendix may be palpated but less reliance should be placed on this than on a deep soreness on pressure which can usually be elicited.

The simplest variation from this standard type is that which is consequent upon an abnormally situated appendix. It is well known that the cæcum is variable in its situation. The embryonic rotation of the cæcum may be interrupted in various locations. It may be unusually high, low or even in exceptional instances upon the left side. The appendix also, as previously dwelt upon, may be long or short and may point in all directions of the compass. A high appendix may give symptoms that correspond more to the location of the gall-bladder, the duodenum or the kidney. A low appendix when inflamed sometimes irritates the bladder, rectum or internal genitalia. The retro-cæcal appendix at times gives pain in the loin or back and movement of the psoas muscle causes pain by disturbing the inflamed member. When it chances to lie in proximity to the ganglia or nerve trunks supplying the inguinal region or thigh the pain may be referred to the terminals of these nerves. Exercise commonly aggravates the symptoms in the retro-cæcal appendix and at times in other varieties. The soreness elicited in these cases is also shifted to correspond to the location of the appendix. In these cases a careful history eliciting perhaps an attack characterized by pain of intestinal character, such as colic or nausea, is important. Elimination of disease of other organs, which from their location may be suspected, also aids in confirming the suspicion of disease of the appendix. Stone in the ureter should always be considered in obscure cases of pain in the right iliac fossa. I have observed a number of cases which from the history alone could not be distinguished and in some instances operation had been done upon the appendix without

relief of symptoms which were subsequently found to be due to ureteral calculus. The X-ray, catheterization of the ureters and careful examination of the urine will usually avoid the mistake. A history of true renal colic is not always to be obtained in these cases. Constipation is the rule in chronic appendicitis but a history of alternating diarrhoea and constipation is obtained in not a few cases.

Careful consideration of these points supplemented by a physical examination of all cases that complain of abdominal pain will usually clear up the diagnosis of these types of chronic appendicitis.

Appendicitis with symptoms that are entirely referred is much more difficult and may be impossible of clinical diagnosis.

I have already emphasized the fact that a normal appendix is a rarity in the adult and that pathologists and clinicians are practically agreed that these departures from the normal are the result of previous inflammations. While it is true that in many instances we are yet unable to develop any history of symptoms referable to the appendix in cases that give unmistakable pathologic evidence of disease, yet there is, at present more than a suspicion that the situation is comparable to that of gall-bladder disease which was formerly thought to give rise to no symptoms in the majority of cases. Just as "symptomless" gall-stones and cholecystitis are shown to be a myth by careful analysis of cases, so in my opinion symptomless chronic appendicitis will be found to have no basis in fact but only in our failure to connect cause with effect. That chronic appendicitis may give no localizing symptoms or signs and yet cause distressing "indigestion" may now be regarded as proved. These symptoms are commonly referred to the epigastrium and are confounded with chronic gastritis, gastric or duodenal ulcer, gall-bladder disease or pancreatitis. The symptoms are extraordinarily varied. Maunsell's definition of appendicular dyspepsia may be quoted, "It is a group of symptoms and perhaps signs, which point so strongly to organic gastric or duodenal disease that it is only by most careful examination or by the supervision of definite appendicular symptoms that a correct diagnosis is probable." I could instance a large number of cases in which I have operated in the expectation of finding upper abdominal disease only to find chronic appendicitis the sole lesion and have had the pleasure of seeing these cases recover entirely from their former symptoms after removal of the appendix.

If this occurred only in cases of a neurotic character it might be explained on the basis of suggestion. If it were an uncommon experience it might be only a coincidence but when it occurs, as it does, so commonly in the experience of every active abdominal surgeon as scarcely to excite remark, the conclusion is irresistible that a diseased appendix may by reflex action influence the function of organs at a distance in such a manner as to cause marked disturbance of that function and consequent symptoms. It has frequently happened also that cases have come to operation for chronic appendicitis whose entire previous history was that of upper abdominal disease until a final attack perhaps more severe has revealed the existence of a diseased appendix, removal of which has demonstrated the presence of long-standing inflammatory changes. The type of appendix which is most commonly associated with referred gastric symptoms is that which contains one or more appendicular calculi in its distal portion.

It must, of course, be remembered that disease of the upper abdominal viscera may coexist with chronic appendicitis. There is considerable evidence for the belief that appendicitis is one of the causes of infection of the biliary tract and the suggestion is made, not without some show of reason, that pyloric and duodenal ulcer are at times the more or less direct result of chronic appendicitis. Hæmatemesis has been met with not a few times without demonstrable disease of the stomach but in association with chronic appendicitis.

The phenomenon of **pylorospasm** has been definitely connected with some cases of chronic disease of the appendix. The so-called secretory neuroses also seem at times to be dependent upon the same cause. It is not difficult to realize that reflex disturbance of the functions of the stomach by appendicular disease may easily lead to erosions and finally gross ulceration. Finally, the close functional interdependence of the gastro-duodeno-hepato-pancreatic system permits ready derangement of any one of these organs by vicious functioning of any one of the members of the system and the creation of a *locus minoris resistentiæ* for the implantation of infection. It is therefore readily seen that the diagnosis of chronic appendicitis of this type may be extraordinarily difficult and even impossible from a clinical standpoint. It also points the suggestion that indigestion of any type whatsoever should lead to the development of a

careful history bearing upon the possibility of appendicitis and should necessitate careful and repeated examination of the region of the appendix.

The simulation of pelvic disease in women and the influence of chronic appendicitis and appendiceal adhesions in the pelvic disorders of women have received attention in another chapter.

Taking all facts into consideration the diagnosis of chronic appendicitis is found to be easy only when there is a definite history of acute exacerbations, otherwise its symptoms are most diverse and baffling and it should always be considered as a possibility however strongly the symptoms may point to organic, gastric, duodenal, hepatic or pancreatic disease.

Removal of the appendix is the only treatment to be recommended for any form of recognizable chronic appendicitis. Only the strongest contraindication to operation should be permitted to weigh in the scale against operation, the only alternative being general medical hygiene which can accomplish little, if anything, in the majority of cases.

SUMMARY.

There is no constant relationship between the symptomatology and the pathological alterations.

Of acute appendicitis there are "three cardinal symptoms"—pain, tenderness, and rigidity of the abdominal wall.

The pain is at first colicky, and is referred to the umbilical region; later, it becomes localized at the site of the appendix.

Tenderness on pressure is always present, and is sometimes best elicited by rectal or vaginal examination. The point of greatest tenderness is usually over the site of the appendix.

The rigidity of the abdominal wall is usually right-sided. It follows the localization of the pain, and is most marked over the inflamed area.

Vomiting is common at the onset of the attack. It desists in favorable cases. Its continuance is an unfavorable symptom.

In chronic appendicitis the history is important. Localized pain and tenderness are the most constant symptoms. Palpation is a most valuable means of diagnosis.

APPENDICITIS IN CHILDREN.

The frequency of appendicitis in early life has in the past been underestimated. Our experience has shown that it is by no means uncommon in childhood and not rare in infancy. Indeed, were the diagnostic difficulties in infants not so great it would be found that many cases of obstinate and severe gastro-intestinal disorders had their origin in but a small portion of the intestinal tract—the appendix vermiformis.

There is, however, abundant evidence that appendicitis increases in frequency from birth to puberty, and that it is far less frequent in childhood than in early adult life. It is difficult to estimate the comparative frequency of appendicitis in childhood and in adult life, not only because of the difficulty of its diagnosis in the very young but also because it is difficult to obtain absolutely corresponding figures of hospitals receiving either only adults or only children.

In the six years ending December 31, 1910, there were operated 1970 cases of acute appendicitis in the German Hospital and 468 cases of acute appendicitis in children in the Mary J. Drexel Home which receives all cases of sickness in children under fifteen years of age under the care of the affiliated institution. During the same period 2100 cases of chronic appendicitis were operated on at the German Hospital in comparison to 130 cases at the Mary J. Drexel Home. In a series of 1000 consecutive cases of appendicitis McCosh found 153 in children under fifteen years. They were distributed as follows:

Up to 5 years.....	17, 1.7 per cent.
5 to 10 years.....	51, 5.1 per cent.
10 to 15 years.....	85, 8.5 per cent.

In a corresponding series of 500 cases of appendicitis at the Mary J. Drexel Home compiled by Dr. H. C. Deaver there were:

Up to 5 years.....	40, 8 per cent.
5 to 10 years.....	180, 35 per cent.
10 to 15 years.....	280, 56 per cent.

Under five years we, as a rule, find the disease quite rare in infants. Of the seventeen cases reported by McCosh under five years, three occurred in children from one to two years old; one from two to three years; seven from three to four years and six from four to five years.

Early cases of appendicitis have been reported by Bamberg in an infant five weeks old; by Blumer and Shaw in one of seven weeks old; and by Dennis and Goyens in two infants six weeks old. Dun of Glasgow in an extended series found none under twelve months old. The case reported by Dixon of appendicular hernia in which there was a gangrenous appendix in the sac of a strangulated inguinal hernia may have been one of primary appendicitis.

The rarity of appendicitis under two years of age may be explained by several facts. In the first place the anatomical configuration of the parts does not so markedly predispose to imperfect drainage and to congestion as it does in later life. The appendix is relatively larger, the drainage is therefore better, obstruction to the lumen being of more unusual occurrence; and the cæcum is as a rule situated higher in the abdominal cavity; there being less tendency toward stagnation in the radicals which carry the blood from the appendix to the superior mesenteric vein. Moreover, the infant's usual position is either supine or prone, and this may possibly tend to prevent congestion. A more important reason is the character of the diet, which, being chiefly fluid, renders the stools soft, and is not so apt to cause serious indigestion as is the food partaken of by older children. The bowels are also emptied oftener in infants, and thus the colon, which becomes more fixed as age advances, is not subjected to such strain. Very possibly many cases of appendicitis in infancy are overlooked.

As to sex, we have found as in adults, a predominance of males in the appendicitis of children. Thus of 500 cases at the Mary J. Drexel Home 315 were males and 185 females. This is a slightly greater proportion of females than other statistics have shown.

The **pathological anatomy** of appendicitis in children varies somewhat from that in adults. Suppuration, localized in the vast majority of instances, is much more usual than in adults. Thus of 403 cases of acute appendicitis in the 500 previously quoted, 243 had local abscess, 12 had general peritonitis and 43 had diffuse

peritonitis. The fact that in 39 instances the abscesses were multiple seems to indicate that multiple abscess is more common in children than in adults. It must not be forgotten, however, that the frequency of abscess may be due in large measure to the fact that the cases are not diagnosed sufficiently early.

As to the appendix itself it appears from the statistics of various investigators and from our own that perforation and gangrene or either condition are found in about the same percentage of cases as in adults. According to Riedel faecal concretions are more common in children than in adults and strictures of the appendix are rarer in children than in adults. It is probable that recurrences in children are far more common than is generally supposed and the difficulty of obtaining a correct anamnesis makes our statistics upon this subject unreliable.

The lesions in the appendix itself are those of acute appendicitis at any age and have been fully described in the chapter on pathology.

The **symptomatology** of appendicitis in childhood is in many ways divergent from that in adults. Young children are unable to make themselves understood and we have only the objective signs to guide us. And even in older children it is most difficult to obtain a correct history as children are often led by the questions asked by parents and others to make statements contrary to facts.

Pain, tenderness and rigidity are again the cardinal symptoms. It may be most difficult to distinguish the pain from colic or other forms of pain caused by abdominal disease. Abdominal pain with vomiting may be but the forerunner of one of the acute exanthemata. We have lately had occasion to see such an instance occurring in an adult. The patient was seen by a surgeon and after a hasty examination operated upon. The appendix was normal but the day following the operation the typical rash of measles made its appearance.

The fever in appendicitis in children is apt to be higher than in adults, children in all cases showing greater variations of temperature for corresponding pathological conditions. According to McCosh and our own experience persistent and excessively high fever favors the existence of gastro-enteritis rather than appendicitis. Vomiting is often marked and persistent. Dun of Glasgow has called attention to the frequency of diarrhoea in his cases of appendi-

citis in children. While it is by no means unknown to find diarrhœa in a child having appendicitis it is not common and hardly to be regarded as a point in favor of the diagnosis of appendicitis. Tenderness on rectal examination is also mentioned by Dun as being commonly found in appendicitis of children. This may be accounted for by the frequency of pelvic inflammation as a result of appendicitis in children, but cannot be considered as a sign to be observed in the majority of instances. This leads us to mention that rectal examination should never be neglected when we suspect appendicitis in a child as it is of the greatest importance both in the diagnosis and differentiation of the disease.

On the whole the onset of acute appendicitis in a child comes with suddenness and severity. The patient gives every evidence of being quite ill and even comparatively mild lesions give marked reaction in temperature, pulse and leucocytosis.

The **differential diagnosis** is often a matter of some difficulty.

Gastro-enteritis with colic must be eliminated. McCosh has mentioned continual hyperpyrexia as favoring this diagnosis rather than that of appendicitis. In colic and gastro-enteritis vomiting is not usually so persistent as in appendicitis while purging is usually more marked. There may be abdominal distention but rigidity is not a marked feature. Even the voluntary rigidity in infants relaxes far more easily than that which takes place in an effort to protect an inflamed appendix. Localized and severe tenderness over the appendiceal area points to appendicitis. While in gastro-enteritis there may be a vague tenderness in the right iliac fossa it never has the character encountered on palpation over an inflamed peritoneal area.

Next in importance in the differential diagnosis is **intussusception**, a not very infrequent condition in childhood. While very early in appendicitis we may have the formation of a mass it rarely takes on the definite contour and peculiar consistency of bowel in which intussusception has occurred. The tenesmus associated with intussusception may be mimicked in appendicitis, although this is hardly true of the constant painful discharge of mucus and blood from the rectum which we have in the former condition. Pain followed by vomiting ushers in the intussusception as well as appendicitis. Intussusception is, however, rare in older children, the

pain is paroxysmal, early collapse is common, and the evidences of obstruction soon set in. In spite of these differences in the symptomatology the differential diagnosis between the two conditions may be difficult.

Diaphragmatic pleurisy and **basal pneumonia** in children often give symptoms which may be confused with those of acute appendicitis. Sudden onset with pain, vomiting and a chill may occur in appendicitis just as in pleurisy or pneumonia, and the pain resulting from a thoracic condition is often at first referred to the abdomen, oftenest high in the upper quadrant, but occasionally seemingly localized in the right iliac fossa. I have upon several occasions seen cases diagnosed as appendicitis in which the course of events clearly demonstrated that the intra-thoracic condition present was entirely responsible for the symptoms.

The **treatment** of appendicitis in children is precisely that in adults.

The **prognosis** is essentially identical with the prognosis in adults, possibly somewhat more favorable.

TYPHOID APPENDICITIS.

Typhoid appendicitis includes a number of lesions. It may be considered as meaning one of three things.

(a) True typhoidal appendicitis, *i. e.*, one due to the bacillus typhosus occurring during the course of typhoid fever.

(b) Intercurrent appendicitis during an attack of typhoid fever.

(c) Appendicitis due to the bacillus typhosus without other typhoid lesions.

There can be no doubt that during an attack of enteric fever, involving as it does the lymphoid structures of the lower ileum and the cæcum, there is often to be found a corresponding infiltration of the lymphoid tissue in the appendix. Hopfenhausen found in a study of thirty persons who died of typhoid fever, that the appendix was involved in eighteen, and in four of these the appendix was held directly responsible for the death of the patient. It is questionable whether every case of involvement of the lymph follicles of the appendix during typhoid fever is to be considered as of specifically typhoidal origin. Perrone in a consideration of appendicitis during typhoid fever emphasizes the fact that while we may have a true lymph-follicle affection of the appendix in the course of the disease that the typhoid infection may act merely as a predisposing but not actually causative factor. To this second form of lymph-follicle involvement he gives the term "paratyphoid of Dieulafoy," the latter surgeon having been one of the first to make a careful study of the subject. The term in English is unfortunate and should not be used, as "paratyphoid" is commonly applied to infections of the intestinal lymph follicles caused by organisms cognate with, but in some ways differing from, the bacillus of Eberth.

Perrone states that the second form of lymph-follicle involvement is quite common but generally unrecognized. This is certain, for as we have not only during typhoid fever but in every enteritis and colitis some infection of the appendiceal area, slight tenderness on deep pressure in this region will not arouse particular attention.

The second form of typhoid appendicitis is a true intercurrent appendiceal inflammation encountered during an attack of enteric fever. This has been noted in many instances. Perhaps in a majority of cases this may find a predisposing cause in the secondary lymph-follicle inflammation described by Perrone. There is no especial immunity to appendicitis conferred upon the patient by pre-existing typhoid fever, so that even were there no predisposing lymphoid congestion, we should expect to find in a certain number of cases of typhoid fever the occurrence of an appendicitis.

Clinically it would be entirely impossible to distinguish a marked typhoid appendicitis during enteric fever from the intercurrent form, and even at operation they may show points of similarity. It would be possible in a certain number of cases to determine by bacteriological and histological examination whether the condition were a part of the disease or intercurrent, but the difference has but little of practical interest in so far as it might affect clinical diagnosis or surgical treatment.

L. J. Hammond has called attention to the relation of the vermiform appendix to perforation in typhoid fever. He quotes the statistics of several investigators. Cushing found the lesion in the appendix in 9.6 per cent. of his cases of typhoid perforation; Fitz had 3 per cent. in a series of 167 cases and Hopfenhausen had 7 per cent. in a series of 108 cases. Finney gives 5 per cent. as the frequency with which the seat of the perforation is found to be in the appendix. Hammond attaches additional importance to the condition of the appendix because he believes that a considerable number of perforations low in the cæcum and in the ascending colon may be traced to previous disease of the appendix. That is to say the appendix often, even when not actually diseased, acts as a predisposing cause to perforation by reason of the adhesions which have formed and consequent interference with the function of the bowel.

From my own experience I would consider the percentages of perforation of the appendix in a series of typhoid perforations as somewhat high. I have not found appendiceal perforation during typhoid to be other than a rare condition.

In addition to these two forms of appendiceal involvement during an attack of typhoid fever there is a form in which the typhoid

affection serves to produce an acute exacerbation of an already chronically diseased appendix. In other words we really have typhoid occurring in the course of chronic appendicitis and causing the latter to take on a new acute form.

C. Leedham Green reports a case of atypical typhoid fever arousing latent appendicitis in which there was a clear history of appendiceal involvement. Previously stress has been laid upon the importance of typhoid fever as a causative factor in appendicitis in later years. It is possible, however, that in many of the patients in whom this has seemed to be the sequence of events the typhoid fever acts merely as the stimulus arousing to activity a pre-existing but latent appendiceal lesion. Especially would this seem probable in view of the frequency with which patients are apt to overlook mild symptoms referable to subacute or chronic appendicitis.

The third great group of cases of typhoid appendicitis is that in which we have cases of appendicitis due to the bacillus typhosus without other lesions of typhoid fever. These patients present the clinical signs of appendicitis and not of typhoid fever. I have had an instance of this condition. John B. Roberts reports a case of perforating typhoidal appendicitis in a boy of nine. His examination showed that the lymphoid structures of the appendix were affected just as the lymphoid structures in the intestine. W. R. Stokes and A. L. Amick report a case of typhoid appendicitis without other intestinal lesions. The attack was a typical one of acute appendicitis and after operation eventuated in recovery. They conclude that the infection was limited to the appendix because forty-eight hours after the appendectomy the patient's temperature dropped to the normal. In this instance the bacillus pyocyaneus was found in conjunction with the bacillus typhosus.

As to **diagnosis**, the several groups of typhoid appendicitis present different problems. In the third group, that in which the appendix alone is involved, we have the simple differentiation between acute appendicitis and typhoid fever—usually not a distinction very difficult to determine. This will be fully dealt with in the chapter upon Differential Diagnosis.

The diagnosis of those cases in which we are led to suspect the presence of acute appendicitis during an attack of typhoid fever is a matter of far greater difficulty. We may take it for

granted that it will be impossible clinically to differentiate those cases which are due to the bacillus typhosus and those in which we have an intercurrent appendiceal involvement due to other organisms.

The classical symptoms of acute appendicitis at all times are pain, tenderness and rigidity. Should the onset be quite acute the pain is often followed, but never preceded, by vomiting. In a patient suffering from typhoid we often encounter sufficient abdominal rigidity and tympanites to render an exacerbation of these symptoms difficult to determine. In practically all cases of enteric fever also there is a certain amount of tenderness upon deep pressure in the right iliac fossa—this being the location of the highly inflamed lower ileum. In highly neurotic or susceptible individuals examination hastily carried out might lead to a suspicion of appendicitis. The pain of appendicitis occurring during typhoid fever, particularly if it be of the true enteric type, is apt to be more insidious and gradually increasing in intensity, accompanied by increasing tenderness and localized rigidity. I have, however, seen on several occasions appendicitis during typhoid coming on with all the classical symptoms strongly marked. The blood count may be of some value in determining the presence or absence of intercurrent appendiceal infection, especially if it be caused by one of the pus-forming organisms. The normal leucopenia of typhoid may give way to a more or less marked leucocytosis. It is well to bear in mind, however, that in typhoid the leucopenia is not at all times present, and that we may have as a result of secondary infections of obscure location a more or less constant leucocytosis. Again, as has been pointed out in the chapter on the blood count in appendicitis, the blood count as regards the presence or absence of leucocytosis is a most uncertain portion of the clinical picture of the disease and not worthy of great reliance.

There are several conditions occurring during typhoid fever with which appendicitis may be confused.

As regards **differential diagnosis**, it is above all things important for the abdominal surgeon to familiarize himself with the clinical aspects of typhoid fever. An unwary surgeon would many a time open up a patient's belly if the physician were not at hand to exclaim that pain in this case was an everyday occur-

rence; that that patient constantly stiffened his abdominal muscles whenever any one came near him; and that time and again the number of leucocytes rose to twelve and even fifteen thousand in typhoid fever without the patient being apparently the worse.

Fortunately it is in the earliest stages of typhoid fever that the diagnosis is most difficult, at a period of this disease when a simple laparotomy is well borne, and hence a mistaken diagnosis is not so serious as it becomes during the third or fourth week of the fever. But even in the early stages a correct diagnosis is not by any means impossible. Pain, tenderness and rigidity, the classical symptoms of appendicitis, may all be present, yet if a history of malaise, headache, epistaxis, and slight diarrhœa is obtained, the case is most probably one of typhoid fever: there may be slight medullary infiltration of the appendicular lymph nodes commencing, but it is not a true appendicitis. The fever is too high and the pulse is too slow. The tongue will often decide the surgeon—in typhoid the typical, furred tongue is observed sufficiently early to warrant its being considered a valuable sign. Even a palpable mass may be due not to an inflamed appendix, but to enlarged mesenteric glands. The blood count is relied upon to a very large extent by most surgeons as a differential mark, and such a count, should be made whenever at all possible. The normal leucopenia of typhoid fever is well recognized, and it is probably safe to say that without an increase in the number of the white blood cells appendicitis is not present, unless the intoxication be overwhelming. This is a matter which is readily determined, as a rule, by the clinical picture which the patient presents.

It has recently been noted by Crile that in a number of cases the onset of peritonitis has caused a marked increase in the blood pressure. This sign might possibly be of service in obscure cases.

From *intestinal perforation*, when this condition is typical, the diagnosis should not be difficult. In typhoid perforation this pain is usually sharp, severe, of sudden onset and quickly subsiding. The pain of appendicitis, is usually less acute, comes on more gradually, is apt to last longer and to be colicky in character. In appendicitis, even if there be perforation, the shock is not so great as in perforations of other parts of the intestinal tract; the pulse rate does not change so suddenly from the slow beat of typhoid

fever to the rapid pulse characteristic of perforation; there is very seldom the fall of temperature which is not infrequently observed in cases of perforation of the bowel; and finally the course of the case, where it is simply watched, and where no operative interference is undertaken, is not so alarmingly rapid to a fatal termination.

From *intestinal hæmorrhage*, which is as a rule unaccompanied by pain, appendicitis is not so difficult to distinguish as it is from intestinal perforation. The hæmorrhage usually declares its presence in the stools in the course of an hour or so; and previous hæmorrhages in the same patient would incline us to favor this diagnosis rather than appendicitis.

Thrombosis of the iliac or femoral veins may be a misleading factor, and may even give rise to a palpable tumor as well as to resistance in the right iliac region. But while this condition presents some of the signs of appendicitis, it has others which are not characteristic of that disease, such as soreness along the trunks of the femoral veins, with œdema of the extremity affected; and it moreover lacks some features of appendicitis, such as the vomiting, the sudden pain, and the intestinal disturbance so common in that disease.

Affections of the gall-bladder during the course of typhoid fever are not usually difficult to distinguish from appendicitis. The symptoms, as a rule, occur in the upper right quadrant of the abdomen, where a well-defined mass may frequently be felt. A history of jaundice with previous similar attacks may possibly be elicited. In any event delay in resort to operative measures during the height of the typhoid fever is even more allowable here than where the appendix is affected.

The **prognosis** of appendicitis during typhoid fever is a matter of much uncertainty, and to the reproach of medicine it must be confessed that it is little influenced by treatment. Yet it may certainly be considered a graver affection than when occurring in an otherwise healthy individual. If the appendix is removed before the inflammation has advanced beyond its first stages, the result will be almost invariably favorable, the influence of such an operation on the typhoid affection in its early stages being practically nil. The inch long wound can be sealed with collodion over the sutures, and the bath treatment pursued without interruption. If, however, an equally simple operation is undertaken during the second or

third week of the fever, it alone may be enough to determine fatally an affection from which, without such interference, recovery would have been uneventful. Still more serious is the case where perforation, gangrene, or suppuration occurs in the appendix, especially during the height of the fever, or in one whose convalescence is not sufficiently far advanced. Yet even such lesions of the appendix during typhoid fever are not so serious as perforations of the ileum: eight cases where only the appendix was perforated, collected by Harte and Ashhurst, gave a mortality after operation of 50 per cent.; while the mortality they give for intestinal perforation in general, when treated by laparotomy, is over 74 per cent.

I have had under my care a case of appendicitis during typhoid fever, where the attending physician was urgent for immediate operation on at least two occasions; but as I was unable to say that an operation would not subject the patient to greater risk than would waiting under constant surgical supervision, and as I could detect no evidence of pus formation, I was unwilling to operate; and in each instance, as it happened, the patient shortly had a fearful intestinal hæmorrhage, and very nearly lost his life; and I could not help feeling that with the added shock of a laparotomy, however slight, he would have been unable to recover. Some weeks after complete re-establishment of his health, I removed with perfect success a chronically inflamed appendix from among numerous adhesions.

Of importance in this connection is the condition mentioned by Perrone, *i. e.*, typhoid peritonitis by propagation as the result of undiagnosed appendicitis without perforation of the latter viscus. Typhoid peritonitis without perforation is occasionally found, but is a very rare condition. We often see a mild peritoneal irritation during typhoid fever, but rarely a frank peritonitis unless there be a perforation. If in these cases the appendix is not perforated it appears more logical to attribute the non-perforative peritonitis to penetration of the bacteria through the large intestinal area involved, rather than through the comparatively small area furnished by the walls of the appendix.

The **treatment of typhoid appendicitis** must vary with the grade of appendicitis and the stage of the fever during which it occurs, and its course during a short period of observation.

A frank acute appendicitis during the early weeks of typhoid fever should be operated upon if it be recognized in its earliest stages, and the operation will probably have no bad effect upon the further course of the disease. The mild appendiceal irritation, if it may be so called, often encountered in the first ten days of an enteric fever will practically always subside without operation just as a corresponding typhoid cholecystitis will under similar conditions.

When the patient has reached the height of the fever any abdominal section necessitating anæsthesia unfavorably influences the subsequent course of the disease. It is wise, therefore, even when a diagnosis of appendicitis can be made to await the evidence that it will not spontaneously subside, rather than to operate upon all grades of appendiceal inflammation at once and during all stages of typhoid fever. If true acute appendicitis be present we should operate in case the progress of the disease indicates the imminence of perforation or further infection of the peri-appendiceal area, but should not tamper with cases which are seen to progress favorably without operation.

DIAGNOSIS.

The diagnosis of acute appendicitis is ordinarily attended by few difficulties. When the three cardinal symptoms of the disease are present—that is, sudden onset of acute abdominal **pain**, followed by **vomiting**, occurring in one previously well; unilateral **rigidity** of the right lower abdominal wall; **tenderness** over the site of the appendix—the diagnosis of acute appendicitis is warranted in nearly every case. The reasons for the failure of the attending physician or surgeon to make the correct diagnosis are errors in theory and in practice. The most important error in theory is his disbelief in the existence or at least in the great frequency of appendicitis as a disease. There lurks in the minds of a great many men a persisting belief in a **primary typhlitis**, whether stercoral or idiopathic, and some physicians even at the present day seem averse to the realization of the fact that it has been proved over and over again that the appendix is always the original seat of trouble in acute inflammation of the right iliac fossa. The picture before the eyes of these gentlemen is that of a cæcum loaded with stagnant fæces, their one idea is to empty the bowel by a drastic purge; and they cannot be convinced that purgation from now until doomsday will not check in the slightest degree the progress of the inflammation in the appendix vermiformis. They have the common habit of speaking of all gastro-intestinal disorders attended by pain, nausea and vomiting, as “inflammation of the bowels.” They make no attempt to localize the seat of this inflammation, and are prone to consider the pathological conditions present merely an “irritation,” even while they call it “inflammation.”

If from the mental horizon of such individuals as these the cæcum could be eliminated, there would appear looming up in the foreground in the position of prime importance that source and fountain of all evil, the vermiform appendix. And if this little worm-like treacherous structure was ever in mind, the greatest error of all, one which I may almost call a crime, *the neglect of physical examination,*

would be absent. Never should any patient who presents pain in the abdomen go unexamined.

Failures in diagnosis, however, may often be explained by the fact that the initial symptoms were insignificant, were lost sight of, or were obscured by the injudicious use of opium. The commencement of an attack of acute appendicitis may very closely simulate acute indigestion, in that there occur vomiting, colicky pains, often implicating the entire abdomen, and tenderness. But in acute appendicitis there is nearly always a certain *sequence of symptoms*—pain, vomiting, tenderness—and rigidity of the rectus muscle is nearly universal. If this sequence of symptoms—(1) pain; (2) vomiting; (3) tenderness—is altered, the diagnosis of acute appendicitis may well be considered doubtful; and where acute appendicitis is present and these symptoms have not occurred in the order described other signs are generally present which render the diagnosis certain. Fever nearly invariably appears later than the three symptoms first mentioned. If hyperpyrexia occurs first, typhoid fever may be suspected, or pneumonia; if vomiting occurs first, acute indigestion or scarlet fever may be the cause; while where tenderness precedes the other symptoms for some hours or days, pelvic disease, or chronic intestinal ulceration are to be considered. These points have recently received special study by Murphy, and to his masterly exposition of the subject too much credit cannot be given.

Not only is the above sequence of symptoms nearly universal, but each of the symptoms mentioned is different in acute appendicitis from what it is in other diseases. Thus the general abdominal **pain** which is usually the first symptom, soon settles to the right iliac fossa, which fact should at once lead to the supposition of more serious trouble than simple indigestion. Although the pain is usually localized to the right iliac fossa it is not always so. It varies with the position of the appendix. But the important point is that it is first, almost universally, general, and then becomes localized; it does not disappear. As already noted in the symptomatology, where the appendix points north the pain may be referred to the lumbar or hepatic region. In certain cases it is referred exclusively to the left side; in such cases the appendix usually points south and occupies the pelvis, but it may point east. The downward and pelvic positions causing pain in the left side must be emphasized, as I

have seen a number of cases in which the attending physicians, who were familiar with the general symptoms of acute appendicitis, were totally misled by the reference of the pain to the left side. The citation of one case, that of the son of a physician, will serve to illustrate the importance of pain referred to the left side as indicative of the pelvic position of the appendix.

Master A., shortly after a meal of indigestible food, was suddenly seized with acute abdominal pain, vomiting and rigidity of the right lower abdominal wall. Symptoms of acute peritonitis developed on the third day, whereupon the father consulted me, stating that he would have regarded the case as one of appendicitis had the pain not been referred to the left side. I told him that in my opinion the disease was appendicitis, and that immediate operation was demanded. Two days later, I was hastily summoned to see the boy, whom I found suffering from a diffuse peritonitis of an active type. He had a pulse-rate of 130 a minute, a "leaky" skin, was constantly retching, and had obstinate constipation. I declined to interfere except to advise discontinuance of opium and all its preparations. Apparent recovery followed. I then advised operation to prevent recurrence, but the father declined to have his son operated upon when in apparent good health. Within ten days a second attack occurred. I was again summoned, but, being absent from home, other counsel was sought, and operation again deferred. Apparent recovery again ensued. Again I was consulted and again advised operation, to which objection was no longer made. At operation the appendix, the tip of which contained a collection of pus, and the whole of which was surrounded by a circumscribed abscess, was found occupying the pelvis, adherent to its floor and to the right side of the rectum. The appendix was removed and an uneventful recovery followed.

It is in this class of cases where the appendix is in the pelvis, and the pain is referred to the left side, that rectal and vesical symptoms may be complained of. Hence the presence of tenesmus, or of vesical irritability, frequent urination, or retention of urine, occurring in cases where other symptoms indicate acute appendicitis, should make us suspect a pelvic position of the appendix.

The pain of acute appendicitis is further characterized by its tendency to subside gradually in the course of four or five hours. If the pain subsides suddenly at any period of the disease, it is usually an indication of gangrene or perforation and operation should be undertaken without delay. When the pain has subsided in the normal manner, that is, gradually, it may not recur in a few cases. In these the appendicular colic has probably been terminated by the lumen of the appendix freeing itself of obstruction. But in

the great majority of cases the pain recurs at intervals of a few hours, and with gradually increasing intensity, becoming finally, after twenty-four to thirty-six hours, nearly constant, and not of a colicky nature.

The **vomiting**, which is nearly always the second symptom, is a reflex act, and is usually not repeated, unless the stomach is full, and has not been emptied at the first effort. When nausea and vomiting recur at a later period, they are an evidence of progressing peri-appendicular inflammation, and, like the secondary pain, are of bad prognostic import. The first reflex vomiting is also seen, as remarked by Murphy, where other hollow organs attempt to free themselves of impacted calculi, as in the case of gall-stones and nephritic colic, or where a vesical calculus becomes impacted in the neck of the bladder; while the secondary vomiting is comparable to that produced by perforation of the stomach, intestine or Fallopian tube.

The **tenderness** of acute appendicitis is of much the same general character as the pain. It is at first diffuse, and later becomes localized to the right iliac fossa, and the point of greatest tenderness, usually McBurney's point, generally corresponds with the position of the inflamed appendix. This localized tenderness is one of the most constant and valuable signs of appendicitis. Both superficial and deep tenderness are present at this stage. The superficial tenderness is due to reflex irritation of the cutaneous nerves, as explained in the section on Anatomy, and is best elicited by gently stroking or pinching the skin, beginning in unaffected areas, and gradually outlining the area of cutaneous hyperæsthesia. This superficial tenderness is generally present from the first, but the deep tenderness does not develop until the stage of appendicular colic is passed. As a rule the superficial sensitiveness is confined to the right iliac region in the shape of a triangle, extending nearly to the median line in front, almost to Poupart's ligament below, and having its apex above the anterior superior iliac spine in the anterior axillary line; it may, on the other hand, extend back to the spine in the form of a band, or be confined to a small circular area at McBurney's point. I do not think it is so important as some authors would have us believe, nor of nearly such diagnostic value as the deep tenderness due to the inflamed appendix.

In some cases of suspected acute appendicitis palpation of the abdominal wall will reveal only moderate tenderness; the point of most marked tenderness being detected by vaginal or rectal examination. In acute cases it is usually not at all difficult to elicit tenderness. When asked to locate the point of greatest tenderness, the patient will himself almost invariably direct attention to the site of the appendix. Palpation over this region besides detecting marked tenderness, may provoke wave-like exacerbations of pain. In chronic cases it is more difficult to locate tenderness, but deep pressure is nearly always successful, and may reveal a thickened organ. Assistance may be had by comparing the conditions upon the opposite side of the body.

There is usually a close relationship between the degree of tenderness and the progress of the disease. As a rule, increase of tenderness denotes progression of the inflammatory lesions, while decrease of tenderness occurring without the administration of anodynes generally indicates subsidence of the inflammation. Unlike pain, tenderness as a rule does not disappear at the onset of gangrene or perforation of the appendix, but usually becomes more marked. If pus is present the pain is usually exquisite, especially if the pus is under tension. Palpation after the first twenty-four hours of an acute attack should be extremely cautious and gentle, as a small abscess not easily detected may be unwittingly ruptured with disastrous consequences. Where the abscess is larger, it is both more evident, and the tenderness is less, as septic absorption may have progressed to such an extent that paralysis of the nerve filaments has occurred. Under such circumstances, however, the other signs of acute appendicitis are unequivocal. Tenderness is marked in any peri-appendicular suppurative peritonitis, whether it owe its origin to ulceration, with or without perforation, to gangrene, or other cause. In general peritonitis the tenderness is widespread.

The **rigidity** of appendicitis is also a reflex phenomenon, due to the stimulation of motor nerve filaments, as explained in the section on Anatomy. It is a rigidity that is not produced by palpation, but which exists before palpation is attempted; and is hence evident upon very gentle pressure. In the majority of cases it is confined to the right side, and most frequently to the lower half of the rectus muscle of that side. It is well known that the gall-bladder,

when distended is similarly protected by its overlying muscles, and inflamed joints are held rigid by their enveloping muscles, for the same reason, as long ago pointed out by Hilton. When the pain and tenderness are on the left side, the rigidity is more pronounced on that side. If the diseased appendix and a consequent appendicular abscess occupy the pelvis, the abdominal rigidity will be bilateral, as is illustrated by the following case:

Miss —, about two weeks prior to my first visit, was suddenly attacked by what at first seemed to be acute indigestion. It did not yield to ordinary medication. In view of the fact that the spleen was enlarged, that spots were present upon the abdomen, and because the temperature was irregular, a provisional diagnosis of typhoid fever had been made. On the other hand, the suddenness of the onset of the affection, the acute abdominal pain, the decided bilateral rigidity of the lower abdominal wall, the irregular temperature, the great pain produced by rectal and vaginal examination, and the characteristic fullness of the pelvis rather indicated appendicitis with a large collection of pus in the pelvis. I advised immediate operation, but adverse opinion of other counsel caused postponement for two days. Operation disclosed a large collection of malodorous pus, and the appendix, which was perforated, occupying the pelvis. The abscess was evacuated, the appendix removed, and an uneventful recovery ensued.

This muscular contraction is at times confined to certain fibres of the flat muscles of the abdomen, for reasons discussed in the section on Anatomy. Where this is the case a hasty examination may lead the surgeon into the error of thinking that the diseased appendix is superficial, and that he feels it just beneath his fingers; on opening the abdomen he will then be surprised to find it several inches distant from the anterior abdominal wall, perhaps even posterior to the cæcum. In palpating for a chronically inflamed appendix other structures may also be mistaken for it; among these are the outer border of the rectus muscle, the semilunar aponeurosis, the inner border of the internal oblique and transversalis muscle, and the anterior crural nerve coursing along the outer border of the psoas muscle.

Elevation of temperature is present in the early stages of acute appendicitis with remarkable uniformity. Murphy says he would not operate upon a case where he was convinced that there had been no fever at any time. But the fever is neither the first symptom nor is it marked. Frequently it never is as high as 100° F.

It rarely appears for several hours after the onset of the attack. Its sudden disappearance is significant of gangrene or perforation. Its persistence and increase is usually caused by peritoneal involvement without perforation. As pointed out by Murphy, elevation of temperature is indicative of septic absorption; when gangrene occurs or when an abscess ruptures, absorption is temporarily stopped, in the first instance by destruction of the absorbing surface, in the second instance by decrease of tension. A secondary elevation of the temperature indicates involvement of a new tissue.

A careful consideration of the nature and cause of the **local distention** is sometimes demanded. This fullness, as has already been stated, may be due to peri-appendicular peritonitis and to inflammatory lesions—serous and cellular infiltration—of the abdominal wall. In certain cases the œdema of the abdominal wall, associated with symptoms of another disease, may lead to the false impression that the affection is not appendicitis, as is illustrated by the following instance:

Miss H. became ill ten days prior to my examination. She had presented the usual manifestations of acute appendicitis, but owing to slight jaundice and decided œdema of the tissues overlying the hepatic region and the lower right chest, there was some doubt in the mind of the attending physician as to the location of the inflammatory process. Upon pressure there was more pain over the œdematous area than over the usual site of the appendix. From a review of the symptoms of the patient from the onset of the attack, however, I concluded that the case was one of suppurative appendicitis, and that the organ pointed north and was located behind the cæcum. Operation confirmed the correctness of these views. The appendix, gangrenous and separated from the cæcum, was post-cæcal, and surrounded by a collection of pus which extended behind the liver and inward to the vertebral column. Recovery ensued.

While the local swelling is frequently due to an abscess, cases are seen where tympanitic distention of the cæcum or intestines causes the whole right iliac fossa to bulge; and where an abscess is absent or very small, a palpable tumor is often formed by a mass of infiltrated omentum, coiled around the inflamed appendix; and, as previously mentioned, the band-like contraction of some fibres of the rectus muscle may be mistaken for the appendix.

Peri-appendicular suppuration is thus to be suspected if, after the initial symptoms of acute appendicitis have been observed, the pain, temperature, but especially the tenderness persist, and when a

palpable tumor is present. Gangrene without suppuration or perforation is indicated by sudden cessation of the pain previously localized in the region of the appendix, fall of temperature, increased pulse-rate, anxious facial expression, and more or less relaxation of the skin, perhaps by perspiration. Rigidity often disappears when gangrene occurs, but usually persists when perforative peritonitis develops.

Leucocytosis is of value as a confirmatory symptom. If the patient reacts well to the infection, the white blood count will be high. If on the other hand the system is overwhelmed by the infection the number of leucocytes may not be increased from the normal.

Serum Diagnosis.—Acting upon the assumption that the bacterium coli commune is the predominant factor in the bacterial origin of most cases of acute appendicitis, and that the general symptoms of the disease are, at least in great part, due to the toxin of this bacterium, some investigations bearing upon the applicability of the Widal test with this bacterium were undertaken in the Pathological Institute of the German Hospital. It was hoped that this test might prove of some value in the diagnosis of the disease, more particularly in obscure cases, or that it might furnish a clue to the identity of the causative bacteria or to the severity of the infection in individual cases. No definite results, however, were obtained.

SUMMARY.

In the diagnosis the three cardinal symptoms are most important:

1. Sudden acute abdominal pain in one previously well.
2. Unilateral rigidity of the lower abdominal wall.
3. Tenderness over the site of the appendix.

The order of the symptoms—(1) pain; (2) vomiting; (3) tenderness—is very characteristic.

The clinical course of each symptom is characteristic. The pain is first diffuse, and later settles in the right iliac fossa. The vomiting is usually not repeated. The tenderness is general at first, but is soon localized to the region of the appendix. Rectal and vaginal examinations are always valuable, but should never be neglected

when abdominal tenderness is not marked or when confusion with tubo-ovarian disease is possible. The fever does not usually appear until after the lapse of some hours; next to never is it the first symptom. It is rarely high at first.

Tenderness is increased in:

1. Pus formation.
2. Gangrene of the appendix.
3. Perforation of the appendix.

Tenderness is decreased:

1. Late in suppurative cases when sufficient toxins have been absorbed to paralyze the peripheral nerve filaments.
2. Upon the subsidence of the disease.

Abrupt cessation of pain may indicate gangrene of the appendix.

Pain and tenderness on the left side indicate that the appendix points south (rarely east) and occupies the pelvis. In these cases vesical symptoms are common.

Pain on the left side with tenderness over the pubes indicates that the appendix points south and that the tip of the organ alone is involved, or that it is the seat of the most intense inflammation.

Pain over the hepatic or the right renal region, with tenderness over the course of the ascending colon, indicates that the appendix is either post-colic, or post-colic and post-cæcal, and that it points north.

Fullness appears late—after the development of an inflammatory mass or the occurrence of suppurative peritonitis.

Excruciating tenderness is the most reliable sign of pus. A high leucocytosis with high polynuclear count is confirmatory.

Distention:

1. Localized—is due to localized peritonitis.
2. General—is due to:
 - (a) Constipation.
 - (b) Administration of opium.
 - (c) Intestinal paralysis, the result of sepsis.
 - (d) Mechanical intestinal obstruction.
 - (e) Diffusing peritonitis.

A chill denoting pus formation is rare.

A tumor often cannot be detected on account of the tenderness and rigidity. When adhesions and infiltration are present, a tumor

is usually palpable. Rectal examination is often successful in determining the presence of a tumor or fullness when abdominal palpation is entirely negative.

An abscess may give a tympanitic note on light percussion due to overlying bowel as well as to gas contained within the abscess.

The occurrence of a chill or chills early in the disease may be indicative, particularly when followed by high temperature, of gangrene; also may be due to nervousness. Chills late in the disease when followed by sweating are indicative of pus, or of the development of pylephlebitis and hepatic abscess.

DIFFERENTIAL DIAGNOSIS.

While in the majority of cases the recognition of appendicitis is not especially difficult, there are, nevertheless, some affections that in many respects so closely simulate it as to give rise to perplexities in the endeavor to discriminate between them. Of these the most important are various disorders of the gastro-intestinal tract, particularly typhoid fever and other morbid conditions attended by ulceration and possible perforation of the bowel; disturbances of the gall-bladder; and, especially in the female, disease of the genito-urinary organs. There are, in addition, other rarer conditions which engender difficulties in the effort to establish a differential diagnosis, and which, in consequence, demand consideration.

Certain of these conditions are acute and simulate an acute attack of appendicitis, while others give rise to symptoms which lead us to suspect chronic appendicitis of either the recurring or latent form.

The diseases which may be confounded with appendicitis may be conveniently grouped in several classes based upon their anatomical and physiological relations.

ACUTE GASTRO-INTESTINAL INFLAMMATIONS.

These furnish us with a class of cases which give close resemblance in their onset to acute appendicitis. The more common are acute gastritis, acute gastro-duodenal catarrh, acute enteritis, and, as allied conditions, simple intestinal colic, dysentery, and colitis.

In all of these inflammatory conditions mentioned we have, as a rule, the history of the ingestion of some food, indigestible either because of its quantity or quality (and not infrequently after some unusual fatigue), followed shortly by nausea, vomiting, flatulence, colic, and in those forms in which an enteritis is present, by diarrhœa.

The history of the case will in every instance be a guide of value in the diagnosis, though too much stress must not be laid upon it, as an attack of appendicitis may follow the taking of indigestible food, or may even be a part of the acute gastro-enteritis itself.

The main differential features in each of these conditions are to be sought in a careful physical examination. We have seen that in appendicitis there is a history of pain followed by vomiting, and this again by tenderness, rigidity and fever. The initial pain in appendicitis is very like that of acute gastritis or gastro-enteritis of any form, but in any of these conditions the nausea or vomiting usually precede the pain. Tenderness is less constant in the conditions noted, and in none of them is it localized in the right iliac fossa even when exceptionally it is present. Indeed it is a well-known fact that colic under these conditions is alleviated by pressure, not accentuated. While again, rigidity may at times be found it is of a more general nature and easily overcome by persistent pressure. Each of these special conditions also has certain features which render it distinctive in symptomatology.

Acute gastritis with some rise of temperature might resemble the very onset of appendicitis, but the absence of tenderness and rigidity in the right iliac fossa would soon render the diagnosis clear. The pain is never localized in the appendiceal region and as a rule promptly disappears after the stomach has been emptied by vomiting. Dietetic indiscretions, cardiac and hepatic diseases are marked predisposing factors.

Acute gastro-duodenal catarrh shows itself by similar symptoms, at times associated with a slight icteric coloring of the skin and sclera. It is similarly differentiated from appendicitis. There may be some rigidity, but when the latter does occur it is bilateral, localized to the upper abdomen and quite transient.

Intestinal colic or **enteralgia** should offer no real difficulties in diagnosis. Appendicitis may be excluded by examination.

Acute enteritis in the adult is usually not difficult to recognize. In children it may be very hard to distinguish from appendicitis with diarrhoea. Here the history is not to be obtained and the abdominal examination may give us nothing of value. Added to this is the fact that in children diarrhoea is far more common in

appendicitis than in adults. A painstaking physical examination will, however, if repeated and made when the voluntary spasm of the abdominal muscles is in abeyance, in most cases give us some clue to the real nature of the disease. Rectal examination may be of value. A certain distinction between appendicitis and enteritis in the young may be entirely impossible, because the two conditions may merge. The presence of high fever would favor a gastro-enteritis. McCosh and M. Mathes have called attention to the presence of marked left-sided pain in appendicitis as pointing to a concomitant enteritis, that is, a colitis with retro-peritoneal lymphangitis. E. Frank has recently performed a series of autopsies on children who had died of acute gastro-enteritis. He found that the appendix was invariably greatly involved, and especially at its tip. It is easy to see how, under these circumstances, enteritis might give rise to appendicitis, and that only repeated physical examinations would show us when the borderline had been passed. An additional point of similarity has lately been pointed out by Dun who has found that tenesmus is quite common in children who have appendicitis. This has not been my experience.

Dysentery and **colitis**, which are merely special forms of enteritis, may in equal measure simulate appendicitis and in the same manner be distinguished from it by physical examination.

The following general statement may be made of the differential points involved in the group of acute catarrhal affections of the alimentary tube.

The character, the mode of onset and the exact location of the pain are of great importance. The pain of the gastro-enteritis group begins gradually and as a rule is *preceded* by malaise and often by nausea. The pain of appendicitis more often occurs suddenly and is *followed* by nausea and vomiting. The pain of gastro-enteritis is distinctly colicky with intermissions, that of appendicitis, while it may be colicky, is more apt to be sharp and constant. In gastro-enteritis the pain shifts corresponding to the segment of the intestine in which the painful vermicular contraction is going on. In appendicitis it is constant at first in the umbilical or epigastric region, later in the region of the appendix. Movement aggravates the pain of appendicitis when the serous surface has become involved, as it usually does early in severe attacks, by causing inflamed sur-

faces to rub against each other. It often relieves colic by relieving tension upon the contracting segment. As a result colicky patients are restless and toss about in bed while those who have peritoneal inflammation are quiet and do not like to change their position. Pressure often relieves colic while it aggravates the pain of peritonitis. Early profuse diarrhœa is common in enteritis, rare in all but the pelvic forms of appendicitis.

In enteritis distention and borborygmi are early features. Distention in appendicitis comes as a rule only after the development of peritonitis.

In the gastro-enteritis group true localized rigidity and tenderness are absent. The rigidity is to a large extent voluntary and may be overcome by patience. In appendicitis the muscular guard is unremitting. Tenderness in gastro-enteritis is diffuse and often shifting, in appendicitis, localized and constant.

The leucocyte count is of little assistance as it may often be high in enteritis.

It may not be out of place here to reiterate the warning against the use of opiates, in either adults or children, when we have to deal with a condition which in its onset resembles appendicitis and again to insist upon a proper physical examination, even when we are most certain that there is simply "colic" or "gastritis."

Enterospasm.—I do not consider this a clinical entity. When symptoms which have been described under this name occur they resemble those of chronic appendicitis. Hawkins, who has especially studied this condition, has found that it occurs generally in neurasthenics, is always associated with constipation, and that the pain occurs generally on the right and left sides. Upon further study it will be found to be either a manifestation of the neurasthenia which it accompanies or of an underlying chronic entero-colitis. A knowledge of its occurrence, however, will make us bear the possibility in mind. The author quoted has found that the pain in these instances is unrelieved by appendectomy.

Chronic Intestinal Stasis may, according to Lane, cause abdominal pain in varying grades and locations. This may be such as to suggest chronic appendicitis and indeed the appendix is not infrequently found involved in this condition. Lane believes that chronic appendicitis is often secondary to chronic intestinal stasis

being produced by the sagging of the ileo-cæcal region and consequent production of kinks and interference with the blood supply. The leading symptom in these cases is the obstinate constipation of years duration and the patients suffer from so-called auto-intoxication, the chief symptoms of which have been enumerated by Chapple as headache, attacks of nausea, loss of appetite, loss of weight, markedly cold hands and feet, mental apathy, constant foul taste in the mouth, attacks of abdominal distention, general muscular pains, skin staining and, in the female, breast changes in the way of chronic mastitis and cystic degeneration.

DISTENTION OF THE CÆCUM WITH ILEO-CÆCAL PAIN.

This condition has been the subject of an extensive monograph by Singer upon "Pseudo-appendicitis and Ileo-cæcal Pain." Among many other conditions which may closely simulate chronic appendicitis he has called attention to distention of the cæcum due, in most instances, to a spastic condition of the bowel lower down. Not only does the pain resemble that of (latent) chronic appendicitis with no acute attacks, but there is present tenderness in the right iliac fossa with deceptive phenomena upon palpation. He gives as the basis of diagnosis a careful investigation of the history, and even then it is doubtless difficult to distinguish these cases. It is, I think, not as frequent as this author would have us believe, but I feel that in it we may find the cause of some unsuccessful appendectomies in supposed chronic appendicitis, where the diagnosis has been made without a history of definite acute attacks. Further investigation, however, is needed to show us the real frequency and importance of the condition.

PRIMARY TYPHLITIS.

This condition was one which in former years was frequently spoken of in the differential diagnosis of appendicitis. McWilliams, who has written a most thorough article upon the subject, defines it as "A primary localized inflammation of the cæcum which begins in the mucosa and goes on to ulceration and perforation."

I have yet to see such a case. That it may occur is undoubted, but it is extremely rare, and as a point to be considered in the differentiation of appendicitis it is negligible. We have even had reports of such primary typhlitis accompanied by the presence of solid fæces in the cæcum—the so-called “stercoral typhlitis” of the older writers. The possibility of such a stercoral typhlitis is too remote to merit consideration. I have never found solid fæces in the cæcum in an experience involving about 10,000 cases of appendicitis.

CHRONIC GASTRIC AND DUODENAL ULCER.

The rôle of chronic appendicitis in causing the symptoms of so-called dyspepsia which are referred almost if not quite entirely to the upper abdomen has already been discussed. The differentiation of these obscure conditions is not always possible prior to operation. Advantage may be taken of any history of acute exacerbations during which time the true nature of the affection is more apparent. When the appendix is at fault careful examination will usually reveal a very slight rigidity of the muscles overlying the right iliac fossa as compared with the left side. Tenderness on deep pressure over the appendix may also be elicited. Morris has called attention to tenderness on pressure just to the right of the umbilicus over the sympathetic ganglia as a sign of chronic appendicitis. This has not been very helpful to me and I can say the same of Rovsing's sign which consists in distending the cæcum by upward pressure over the descending colon, thereby seeking to bring out distention and tenderness of the appendix. The characteristic history of duodenal ulcer, the intermission of symptoms, their distribution, the regularity of symptoms in relation to the ingestion of food, a history of blood gross or occult in the vomitus, stomach contents or stool must all be kept in mind and if present with a negative physical examination of the right iliac fossa organic disease of the upper abdomen may be expected, but as previously stated the two conditions frequently coexist.

PERFORATION OF GASTRO-INTESTINAL ULCERS.

The perforation of ulcers of various parts of the gastro-intestinal tract may give rise to symptoms similar to those of acute appendicitis.

We must include in our differential diagnosis perforation of gastric, duodenal, cæcal and colonic ulcers and those of the small intestine. Typhoid perforation has already been discussed in the chapter on Typhoid Appendicitis.

Perforated gastric and duodenal ulcers present symptoms so similar both before and after the actual perforation that they must be considered together. In either case the previous history is of great aid. As a rule a patient with an ulcer of the stomach or duodenum will have suffered for some time previously with symptoms referable to either of these organs. By this we must not understand only the so-called classical symptoms, such as localized pain, vomiting, hæmatemesis and indigestion, etc., in the case of gastric ulcer, or pain some time after eating, vomiting, indigestion and intestinal hæmorrhage in the case of duodenal conditions, but also the more obscure phenomena. Many cases of gastric and duodenal ulcer are "latent" and we have in these no symptoms of disease referable to the upper abdomen. Many more, however, formerly classed as latent are now diagnosed and treated before the most severe symptoms and complications set in. The more careful taking of histories and a better understanding of the pathology enable us now to diagnose many cases of gastric and duodenal ulcer which formerly were treated for indigestion, nervous dyspepsia, etc. Added to this we may note the recent methods of demonstration of occult blood in the stomach contents and fæces. In those rare cases then, in which we are confronted with the difficulty of distinguishing between a stomach or duodenal perforation and acute appendicitis the history should be most carefully considered, and in the present state of our knowledge should mean much more to us than in former times.

The prodromal symptoms of perforation of the duodenum or stomach have been the subject of increased investigation of late. They may be noted in the form of vague feelings of increased epigastric distress or fleeting pains of a stab-like character, often brought on or increased by deep breathing or any movement involving the abdominal muscles. Robson and Moynihan mention a patient who said that it hurt her to bend, as her side felt stiff. Mr. Moynihan has lately laid stress on these "inaugural symptoms" in an admirable article.

When the actual perforation takes place it is attended by most acute pain in the epigastric region. The pain is of burning or stabbing character, and is referred to the extreme upper abdomen. Board-like rigidity in this region at once follows. We may or may not have vomiting, at times bloody. The respiration is thoracic and rapid and the face shows signs of extreme agony. In perforated duodenal or pyloric ulcer in many instances the infection rapidly makes its way downward toward the right iliac fossa and if the case is not seen at once there may be extreme tenderness over the appendiceal region, the whole picture suggesting perforation of the appendix with rapidly diffusing peritonitis. This error is a common one in diagnosis. A careful history is the best safeguard but cannot insure against error. The perforation, however, may be a subacute one and all the symptoms be in consequence much lessened in intensity.

INTESTINAL OBSTRUCTION.

Ordinarily there is little difficulty in distinguishing intestinal obstruction and appendicitis. The cases in which trouble arises are the fulminating perforations of the appendix followed by rapidly spreading peritonitis which quickly causes paresis of the bowels and obstipation as marked as in any case of mechanical obstruction. At the outset the diagnosis is not obscure nor is it difficult if a clear history can be obtained but in hospital practice one sees not a few cases of this type in which the patient on admission shows general distention, diffuse tenderness and reports absolute constipation for from twenty-four to seventy-two hours. The region of the appendix shows no more marked signs than the left iliac fossa or mid-abdomen. The temperature is moderately elevated and the pulse accelerated but not more than in the later periods of obstruction. Leucocytosis is of no assistance in differentiation as it occurs in both conditions. Questioning will usually develop the fact that in mechanical obstruction the pain at the outset and for a considerable period was distinctly colicky and remittent in type. Vomiting is more marked in obstruction. Rigidity and tenderness are the chief reliances both being much more evident in peritonitis than in obstruction.

Intestinal obstruction may occasionally be mistaken for appendicitis. The differential points are the presence of hernia, of scar indicating abdominal operation, the colicky character of the pain, slow pulse and normal or subnormal temperature at the outset, the absence of true reflex rigidity or marked tenderness.

MALIGNANT AND TUBERCULOUS DISEASE OF THE CÆCUM.

In the early stages of either malignant or tuberculous disease of the cæcum it is often impossible to differentiate the condition from a chronic appendicitis; its distinction from acute affections is usually not difficult because of the absence of the systemic signs of acute infections.

Carcinoma may be primary in the appendix, and when operation is undertaken before further development occurs, the diagnosis can be made only by microscopical examination.

In carcinoma of the cæcum there is usually a history of recurrent pain at the site of the disease, and an absence of inflammatory symptoms, which strongly resemble that of a simple progressive appendicitis without acute attacks. Blood examination is of little value except that it may show an anæmia. Later on in the disease we may have alternating constipation and diarrhœa with an occasional trace of blood in the stools. The hæmolytic and other laboratory methods of diagnosis of carcinoma are of no value in this condition. When a tumor is found after the persistence of such symptoms, particularly if it be hard or nodular and of slow growth, the diagnosis of appendicitis is definitely set aside. To delay a differential diagnosis until this stage has been reached is at variance with all principles of surgery, and it is hardly proper to quote the signs of a progression of a growth to almost an inoperable stage as valuable points in differential diagnosis. The age of the patient is also a most unreliable sign as carcinoma of the intestines is not rare in the young.

Diverticulitis.—Inflammation originating in diverticula of the large intestine may give a picture in many respects resembling appendicitis. As the great majority of such diverticula are situated in the sigmoid, the symptoms arising from diverticulitis are

as a rule left sided. It has been described by a patient as feeling exactly like appendicitis on the left side. The disease occurs, as a rule, in men past middle life who have been troubled by obstinate constipation for a considerable period.

There may be a history of similar attacks of more or less severity. It is common for an inflammatory mass to form which may be felt in the left iliac fossa or through the rectum or vagina. In the cases hitherto reported the inflammatory masses generated by this condition have frequently been of a chronic character and have often been confused with carcinoma. It is not uncommon, however, for abscesses to form which present the same characteristics and expose the patient to the same dangers as appendicular abscesses, the chief difference being in the location. An appendix abnormally placed on the left side could simulate diverticulitis in every detail. Pelvic appendicitis also as previously stated may give marked left-sided pain and tenderness.

The question of the existence of **perforating ulcer of the ascending colon** may arise in the differential diagnosis between appendicitis and the previous conditions. Ulceration of the colon is most likely to be associated with malignant disease, in which event there are present such symptoms as attacks of paroxysmal pain, followed by small bowel movements, containing more or less mucus, which may be mixed with blood; the presence of a mass; the history of slow onset, and cachexia. When obstruction exists, the distended coils of intestine may be made out during a paroxysm of pain by examination of the abdominal wall.

Mrs. R., aged sixty years, was admitted to the German Hospital June 21, 1897. The diagnosis was carcinoma of the cæcum; ileo-colostomy.

Her father died of kidney trouble; her mother in childbed. Five brothers and two sisters were alive. She had been married forty years and had had eight children. Menstruation was regular after marriage. The menopause occurred ten years ago. She had had bladder trouble for some time. A calculus had been removed from her bladder four years ago. In December, 1896, she had the first attack of her trouble. There developed severe lancinating pain in the right iliac fossa, recurring at short intervals; since then she has passed scarcely a day without pain, sometimes having severe exacerbations. She has frequent micturition, without tenesmus, and some ardor urinæ. She states that a small growth was removed from her urethra in May, 1897. There has been no hæmaturia. She has passed gravel at times, but not lately. There

is considerable sacral ache. Her appetite is good and her bowels are regular. Her tongue is pale, but not coated. She has not lost flesh and there is no marked cachexia.

Examination revealed extreme tenderness in the right iliac fossa, and the right rectus muscle was very rigid, simulating a mass. There was tenderness also on deep pressure in the right vaginal vault. The uterus was small and atrophied; there was no discharge. Catheterization revealed no blood, mucus nor stone in the bladder. The urethra had evidently been dilated.

Operation.—An incision was made over the region of the appendix. A coil of ileum was found to be adherent to the cæcum. A hard mass being felt above the site of the appendix, the appendix was exposed and found to be completely separated from its cæcal attachment. By its removal with the exudate, a large perforation was found in the ileum, just above its junction with the cæcum. The lower end of the cæcum was involved in a carcinomatous growth. The growth was removed by careful dissection, cut away with the cæcum, and the bowel closed with continuous silk suture. The terminal four inches of the ileum were next removed, as its mesentery was infiltrated. The ileum was closed with silk sutures and another portion anastomosed with the transverse colon by means of a Murphy button. Recovery was uneventful.

Where no history of previous disease of the intestines can be elicited, acute perforation, the result of intestinal ulceration or rupture, may so closely resemble an attack of appendicitis that the differential diagnosis may be impossible.

Ordinarily in ulceration of the intestine there is present an area of diffuse pain, confined to that portion of the abdomen overlying the site of the affected bowel. There is also usually a trace of blood or slight intestinal hæmorrhage (hæmorrhoids, of course, being excluded), and pus may be found in the stools. There may be diarrhœa and mucous stools. These may, however, all be absent. The cardinal symptoms of appendicitis may be of value in forming a differential diagnosis between intestinal perforation and appendicitis, since in appendicitis these are usually well marked; they may also, however, be well marked in intestinal perforation or rupture. The lesions in both instances being similar, like symptoms are produced, particularly if the part affected is the terminal portion of the ileum, the cæcum or the ascending colon. The symptoms of intestinal perforation in one previously well are marked: namely, sudden acute abdominal pain, referable to the seat of the lesion, usually accompanied by shock, which in some instances is very profound. There is a leaky condition of the skin and an

anxious expression of the face; the pulse is rapid and thready, the temperature subnormal. With reaction the acute abdominal pain increases, and, if the case be not recognized as an acute intestinal perforation, and cathartics be given, peritonitis supervenes more rapidly than it would if no laxatives were administered.

Contrast these symptoms with those of early appendicitis—the acute abdominal pain, the tenderness, the rigidity of the abdominal walls, nausea and sometimes vomiting. Ordinarily these symptoms occur after the ingestion of indigestible food, or after exposure in some manner. The mere fact that such conditions closely resemble each other, and that it would be impossible under certain circumstances to arrive at a differential diagnosis except by operation, merely emphasizes the propriety of operation in most cases of acute abdominal disease having the symptoms of pain, rigidity and tenderness occurring suddenly in one previously well. The following is a case in point which I deem of sufficient value to relate, in order to show the inability to form a differential diagnosis at times between this condition and appendicitis.

M., aged twenty-eight years, a short time after eating a hearty meal was suddenly seized with acute abdominal pain. The pain was referred to the right hypochondrium at about the region occupied by the gall-bladder. The pain radiated from this point to the umbilicus; there was nausea and vomiting. He took some medicine to allay a sick stomach. The same evening a physician was called, who discovered the foregoing state of affairs. There was disturbance of the urinary secretion, the urine being highly colored, scanty and bile-stained. A diagnosis of acute cholecystitis was made. The patient was given calomel in fractional doses, ice was applied to the abdomen, and milk with whiskey in small quantities was given at intervals of three hours. The following morning the area over the gall-bladder was not so sensitive on pressure, nor quite so rigid as the night previous. The patient presented an anxious appearance, the skin was bluish and leaky, and there was excessive thirst. On account of slight amelioration of the symptoms in the hypochondriac region and the patient's constitutional depression, surgical interference was postponed. The same evening the patient was advised to go to the hospital for operation on account of the symptoms not improving. He did not go, however, until the following morning. Upon consultation the diagnosis was made of acute appendicitis with diffusing peritonitis. The patient's condition was such that operation was deferred until he should react. The usual treatment for appendicitis was instituted. The patient died from general peritonitis.

The necropsy revealed the appendix and gall-bladder normal. There was

a perforation of the ileum about one and a half to two inches from its junction with the cæcum. The abdomen contained fæces. The other organs were normal.

The following clinical history of a patient in the service of Dr. H. C. Deaver at the Episcopal Hospital is of value as showing the close resemblance to recurrent and relapsing appendicitis presented by certain cases of carcinoma of the cæcum:

The patient, a man of forty-one years, was first attacked, about three years ago, with spasmodic pain, rather dull in character, in the right iliac fossa. For a month or more at a time he would be free from all abdominal symptoms. He was habitually constipated, and soon noticed that he was especially costive before one of these attacks. The pain of these attacks lasted as a rule several hours, and was accompanied by nausea and vomiting. His appetite had been failing for a long time, and he had been growing progressively weaker and more anæmic. He thought he had lost forty pounds in weight in the last three months.

Examination showed him to be anæmic and wasted in appearance. His skin had a slightly yellowish tinge. The chest presented no abnormalities. His abdomen was uniformly rigid on palpation, but an indistinct mass could be located on deep pressure over the right iliac fossa. Some tenderness was thus elicited. There was no dullness on percussion. The urine was negative. Examination of the blood showed that there were 15,000 leucocytes and that the hæmoglobin was 45 per cent.

On the fifth of September, 1904, the abdomen was opened over the appendix. This was found on examination to be apparently normal. A mass was felt, however, in the cæcum, which was accordingly delivered through the abdominal wound. The serous coat of the cæcum was smooth and unaffected, but there was a carcinoma involving the entire circumference of the cæcum and part of the ascending colon. The tumor extended almost six inches longitudinally. There appeared to be almost complete obstruction of the lumen of the bowel; and it became evident that the periodical attacks of pain, nausea and vomiting were due to the damming up of fæces on the proximal side of the stricture. The corresponding mesenteric glands were slightly enlarged. This fact, together with the somewhat wasted condition of the patient, made it seem wise to perform a palliative rather than a radical operation. Lateral anastomosis was accordingly done, with a Murphy button, between the lower ileum and the ascending colon; and the abdominal wound closed. The progress of the case after operation was uneventful. No vomiting occurred; gas was freely passed by the rectum; and the highest temperature recorded was 99.6° F. The button was passed by the rectum in due time.

Sarcoma may also occur in the cæcum and may closely resemble chronic appendicitis. The symptoms, however, approach more nearly those of carcinoma, though the development may be more

rapid. Sarcoma of the ileum has also been mistaken for appendicitis.

Tuberculosis of the cæcum is practically always diagnosed as chronic appendicitis before tumor formation. The vast majority of cases of cæcal tuberculosis, as of other forms of intestinal tuberculosis, are secondary, though primary cæcal and ileo-cæcal tuberculosis are by no means unknown. Various types of tuberculosis of this region are described. The ulcerative form, practically always secondary to pulmonary tuberculosis usually occurs when surgical intervention is out of the question, and as a rule affects the lower ileum and cæcum simultaneously. Hypertrophic tuberculosis is usually confined to the cæcum and 232 cases have so far been reported (Rogers). It is usually primary and until its final stages is largely confined to the cæcum.

It will easily be understood that in its incipency the condition will closely resemble chronic appendicitis. The first symptoms may be those of vague attacks of indigestion often accompanied by abdominal pain referred to the right iliac fossa, nausea and vomiting, distention and constipation. When the disease has not progressed to the formation of a palpable tumor and alternate diarrhœa and constipation have not set in a diagnosis of chronic relapsing appendicitis is usually made and is almost unavoidable. Subsequent developments will demonstrate its incorrectness and fortunately the rarity of the condition renders the necessity for such a difficult diagnosis infrequent.

Tuberculosis of the ileum near the ileo-cæcal junction has at times been mistaken for appendicitis. Such a case has come under my observation.

Tuberculosis of the Ileo-cæcal Mesenteric Gland.—This is a condition occasionally met with, and in the absence of associated lesions elsewhere gives rise to symptoms impossible to distinguish from those of chronic appendicitis. Usually it is secondary to disease of the cæcum or appendix.

TYPHOID FEVER.

Differentiation between typhoid fever and appendicitis is an occasional source of diagnostic perplexity, indeed upon several occasions I have seen the surgeon forced to defer operation in appendicitis be-

cause the opinion of the majority of the medical attendants was that the disease was typhoid fever. Follicular abscesses of the appendix are responsible for some mistakes in the differential diagnosis between appendicitis and typhoid fever. The minuteness of the collections accounts for the mildness and the prolongation of the sepsis and for the lessened degree of the local symptoms. In this type of appendicitis there are persistent elaboration and continuous absorption of infectious products, with a small amount of tissue involved. In many respects the temperature record and the general condition in such cases closely simulate irregular typhoid, and much care in examination is essential. It is not uncommon to find supposed typhoid fever cases in which operation has demonstrated the presence in the appendix of very small follicular abscesses varying in size from a millet seed to a mustard-seed, an eroded mucous membrane, and a more or less infiltrated organ. In typical cases of course the symptoms are quite distinct. Those of appendicitis have been discussed. Typhoid fever ordinarily has a slow onset, attended by headache, lassitude and characteristic tongue and temperature record, diffuse abdominal tenderness with relaxation of the abdominal walls and possible gurgling upon pressure over the cæcum, with enlargement of the spleen. When such symptoms as the latter are present there can be but little doubt as to the diagnosis, especially if we have also the typical eruption. An eruption is sometimes found in cases of appendicitis which may resemble that of typhoid fever, but it occurs as a rule late, when sepsis is far advanced.

Our differential diagnosis is easy then with such a clear history of either condition and when we have the typical signs of either disease apparent upon careful physical examination.

Moreover, we have at hand two most important aids to diagnosis by laboratory methods. The Widal reaction in typhoid fever is almost pathognomonic, though its absence does not imply the absence of a typhoid infection. Leucocytosis is very uncommon in typhoid fever occurring only when suppurative complications exist, in fact most cases show a leucopenia or diminution in the leucocyte count. The differential count also shows a mononuclear rather than a polynuclear increase. If time permits a blood culture will often recover the typhoid bacillus.

The diagnosis between the two conditions has been a source of difficulty to me only in some of the early stages of typhoid which have had an atypical onset. In these we do not have a history of continued malaise, etc., but the disease seems to have come on more suddenly, the intestinal distention causes some slight rigidity and some tenderness which may be most marked about the ileo-cæcal region.

DISEASES OF THE GALL-BLADDER AND BILIARY DUCTS.

The various diseases or rather inflammations of the gall-bladder and its associated ducts at times have been a source of confusion in the diagnosis of appendicitis. We have to consider practically only the inflammations, acute or chronic, calculous or non-calculous.

Before entering upon the differential diagnosis we must take into consideration the frequent association of appendicitis, chronic or acute, with lesions of the biliary apparatus. By some authors the appendix is considered the primary focus of disease, by others again the gall-bladder is looked upon as the initial seat of the infection. Be that as it may the coincident inflammation of the two structures has been noted by many authors, such as Riedel, Kehr, Dieulafoy and lately by Singer and others. The latter author inclines to the belief that the gall-bladder disease is primary, but offers no definite proofs. In these cases we have often alternations in the symptom-complex, in which at times one organ, at times the other stands forth as the one at fault, and a number of cases have been reported in which the diagnosis was finally established only by two operations, the first, either upon the gall-bladder or appendix, having failed to alleviate the patient's distress.

The following case is illustrative:

Some two years since I operated upon Mrs. —, who was the subject of acute appendicitis, when I found a gangrenous appendix lying north. The appendix being removed the fundus of the gall-bladder presented; it was distended, deeply injected with exudate surrounding it. While the gall-bladder was found in an inflammatory condition I did not disturb it. On the seventeenth day after the appendix operation, however, it broke down and discharged its contents, pus with bile and finally pure bile. The sinus closed in a comparatively short time, the patient recovered promptly and remains well.

EMPHYEMA OF THE GALL-BLADDER.

In discussing the affections of the gall-bladder in their relation to appendicitis, they may be classed into two general groups. First, the acute inflammations, which include acute phlegmonous or gangrenous cholecystitis and empyema of the gall-bladder, any of which may be associated with the presence of gall-stones; and cholelithiasis by which we may understand gall-stone disease unattended by the more acute manifestations.

Acute cholecystitis of whatever variety is to be distinguished from acute appendicitis not so much by the onset which in either case is liable to be sudden and accompanied by fever and leucocytosis, but by the absence of the typical arrangement of symptoms found in appendicitis and the very definite signs which point to a lesion of the biliary tract. There may be a history of previous similar attacks with possible transient jaundice; and the attacks more frequently follow indiscretions in eating and drinking than is the case in appendicitis, because a duodenal catarrh is a fertile cause of obstruction of the duct and the extension of infection. The pain is from the first more or less sharply localized to the right epigastrium and sometimes radiates to the right shoulder or back. The tenderness and rigidity are also found only about the gall-bladder region. Jaundice may be present but too much stress must not be laid upon its diagnostic value as it is frequently entirely absent in all the varieties of gall-bladder disease.

When the cysticus becomes obstructed the gall-bladder may become distended. In such cases, when the rigidity and tenderness do not prevent accurate palpation the gall-bladder may be felt as a round, tense, markedly tender tumor moving with respiration, beneath the liver margin.

Empyema of the gall-bladder is but a further development of a simple or mild cholecystitis in which we have a frankly purulent and severe inflammation of the viscus with obstruction of the cystic duct. It presents the same symptoms and diagnostic points in more marked degree and the marked constitutional disturbances and localized pericholecystitis so often present render differentiation correspondingly easier.

Acute phlegmonous or gangrenous cholecystitis is the last

and most severe degree of gall-bladder inflammation. Its well marked symptoms leave us as a rule but few doubts as to the diagnosis.

If the gall-bladder ruptures, the pus may, in some instances, gravitate toward the right iliac fossa and give rise to the supposition that this was the original location of the inflammatory process. The differential diagnosis between a ruptured empyema of the gall-bladder and a ruptured appendiceal abscess may be extremely difficult as the rapidly spreading peritonitis obscures our landmarks. The points to be noted are the previous history and the fact that in cases of ruptured gall-bladder the rigidity is most marked in the upper portion of the right rectus muscle.

Cholelithiasis would at first thought seem easy to differentiate from appendicitis, yet this is not always the case. It must be remembered that in perhaps the vast majority of gall-stone cases the symptoms are not the classical ones of the disease, certainly not when they first begin to manifest themselves. The vague digestive disturbances, absence of jaundice and of characteristic pain will often lead us to think of an indigestion caused by a chronic appendicitis. Then again, the symptoms directly referable to the gall-bladder may be entirely absent, while the pain may be entirely referred to the ileo-cæcal region. This referred pain, when accompanied by constipation and secondary cæcal distention, may so closely simulate a chronic appendicitis as to mislead us entirely. Singer has quoted such a case in which, from his description, it is evident that the utmost refinements of diagnostic ability failed to render the condition clear until subsequent developments called attention to the gall-bladder trouble.

Typical biliary colic with its sharp localization and radiation, and accompanying jaundice should not offer any diagnostic difficulties as far as appendicitis is concerned.

Hepatic and perihepatic abscess could be confounded with appendicitis only when in the latter there is, late in the disease, a circumscribed collection of pus in close relation with an appendix which holds a post-colic position and points toward the liver.

Acute Pancreatitis.—This disease is distinguished from appendicitis by the greater severity of its onset and course, persistent vomiting, localization of tenderness and tumescence in the epi-

gastrium, followed frequently in the less severe cases by pain, swelling and tenderness in the left loin. Hiccough, limitation of diaphragmatic movement and the signs of basal pulmonary involvement are also common. The course of the inflammatory involvement of the peritoneum is from above downward rather than from below upward as in the case of appendicitis. The history is of importance. Confusion is likely to arise only in those cases which are seen after peritonitis is fully established and in such cases full importance must be given to the sequence of events which have preceded.

Chronic pancreatitis occurs in older individuals as a rule who have had a history of long-standing indigestion of upper abdominal type. It is to be confused chiefly with latent appendicitis which refers its symptoms entirely to the upper abdomen. The distinction is not always to be made clinically but an opinion may usually be formed by careful examination of the region of the appendix confirming or tending to eliminate the rôle of that organ and by the various tests of pancreatic function with examination of the urine for sugar and by the development of any history of jaundice. Unfortunately for diagnosis but fortunately for individuals who are the subject of chronic pancreatitis, the diseased pancreas may still supply its essential ferments to the digestive tract. Deductions based upon the tests for the demonstration of these ferments must be accepted with caution. Conclusive differential diagnosis must often rest upon the findings at operation.

RENAL IRRITATION BY APPENDICITIS.

Too much stress cannot be laid upon the importance of urinary examinations, not only in all kidney affections, but also in cases of appendicitis.

In most cases of appendicitis examination of the urine reveals slight abnormalities, such as traces of albumin, cylindroids, hyaline casts, renal and ureteral epithelium, leucocytes and, rarely, red blood corpuscles. In the affections in which the kidney and its adnexa are involved early the urine will show characteristic peculiarities.

MOVABLE KIDNEY.

Movable kidney is indicated by the presence of a movable tumor characteristic in shape, which by properly directed pressure can be restored to its normal position. The methods of palpating a floating kidney are well known and need not be dwelt upon here. The condition, except under exceptional circumstances will not give rise to such symptoms that acute appendicitis will be suspected, but the repeated attacks of pain associated with the condition may give rise to a suspicion of chronic appendicitis. The associated neurasthenic condition and frequent general visceral ptosis should put us on our guard at once. The urinary disturbances which accompany malposition of the kidney, the frequent desire to urinate with the excretion of an excessive amount of urine would lead us to examine the patient more closely. While fever and chills may accompany the crises of pain they are rare and we have not the characteristic sequence of symptoms that we find in appendicitis, nor do we have a leucocytosis. Rigidity and tenderness may be found when we have a loose kidney but their location and extent would at once show that they are not appendiceal in origin.

The operator may be thrown off his guard by acute indigestion occurring in a nervous individual suffering at the same time from acute paroxysms of pain due to movable kidney, which was previously not recognized by the patient or physician. Under these circumstances the kidney may become temporarily anchored in its abnormal position. Under the foregoing conditions I have been called upon to operate for acute appendicitis, and could not say definitely that the case was not acute appendicitis until the patient was fully anæsthetized; then, upon palpation, the diagnosis at once became clear. Again, in the presence of both conditions—*i. e.*, movable kidney with acute symptoms and an enlarged appendix due to chronic inflammation—examination under ether will disclose not only the abnormal condition of the kidney, but also the presence of a palpably enlarged appendix. If, under these circumstances the patient has been suitably prepared, an appendicular operation should be performed.

Edebohl, in a series of interesting papers, has insisted upon movable kidney as a cause of appendicitis. He claims that a mov-

able kidney, by dislocating the duodenum and pancreas, compresses the superior mesenteric vessels and thus causes chronic passive congestion of the appendix, since its blood is returned through the superior mesenteric vein. Movable kidney being more frequent among women, he thinks that of 100 women with chronic appendicitis, 81 have movable right kidney as well, and that therefore treatment of either disease alone will be ineffectual in relieving the symptoms; hence he proposes and has practised the performance of nephropexy and appendectomy through the same lumbar incision. Only in a few cases has he found it impossible to reach the appendix through this wound. Personally I think such an operation is a dangerous procedure and cannot recommend it, as I regard separate incisions for the appendix and kidney operations a far safer method. I do not believe that Edebohl's explanation of pain in the region of the appendix is always correct nor that the appendix should be removed in the large percentage of cases of movable kidney which he advocates. I consider that the pain in the right iliac fossa and the tenderness that can be elicited by palpation over the region to which the pain is referred can better be explained by colic due to the pressure of the displaced kidney against the colon. I have been able to demonstrate this in a number of cases where fixation of the kidney alone has relieved the symptoms referable to the right iliac fossa.

DISEASES OF THE KIDNEYS AND URETERS.

The occasions when we are called upon to differentiate between acute or chronic appendicitis and a lesion of the kidney or ureter are not frequent. When, however, such is the case the diagnosis may be one of great difficulty. The structures upon the right side alone must be taken into account in the differentiation and the affections of the kidney or ureter which obscure the diagnosis may be either inflammatory, calculous disease, or the result of alterations in the location of the kidney itself. Neoplasms of the kidney also may call for consideration in exceptional instances.

The inflammatory affections concerning the kidney which may be confused with appendicitis are *pyo-nephrosis*, *perinephritic abscess* and *multiple abscess* of the kidney.

Pyo-nephrosis differs from appendicitis in such marked degree

that a diagnosis should seldom be difficult. Its onset is gradual, the pain radiates from the loin to the umbilical region, groin and testicle, and retraction of the latter may occur. Palpation of a tender mass which moves with and is continuous with the kidney is the most reliable local sign of abscess of the kidney, while irritability of the bladder and the presence of pus and possibly blood in the urine are important confirmatory signs. In every case where a kidney lesion may be suspected a cystoscopic examination with catheterization of the ureters should be undertaken.

Septic Infarcts or hæmatogenous infection of the right kidney may simulate appendicitis. The urinary and physical findings are distinctive.

Ureteritis.—Inflammation of the ureter may occur either as a sequel to inflammation of the bladder or in connection with disease of the kidney. The differential points are: The history, the presence of tenderness at the bladder extremity of the ureter, as made out by vaginal or rectal examination; the presence of deep-seated tenderness along the line of the ureter; and the presence in the urine of pus and blood. Cystoscopic examination will show a pouting inflamed ureteral orifice, possibly discharging pus, and if supplemented by catheterization of the ureter will make the diagnosis clear.

Renal and Ureteral Calculus.—Ordinarily the symptoms of stone in the upper urinary tract are sufficiently distinctive to avoid confusion. In the absence of definite renal colic with its characteristic radiations, however, the pain may strongly suggest chronic appendicitis and if the stone be in the lower ureter there may be tenderness in the region of the appendix. I have encountered one such case in a woman who had already had the appendix removed and subsequently underwent a pelvic operation for pain localized in the right iliac fossa. The explanation of the symptoms proved to be a small calculus lodged in the ureter just above the pelvic brim. No true renal colic had ever been present and the tenderness was so situated as to be indistinguishable from that due to the appendix.

X-ray examination should be made in all doubtful cases and often ureteral catheterization will settle the point, though this is not to be employed routinely but only when there is a well-founded suspicion of renal or ureteral disease.

Renal colic should hardly cause confusion in the diagnosis of

appendicitis except in those instances in which an inflammation of the appendix is associated with pain referred to the umbilicus and also with vesical symptoms, such as tenesmus and frequent micturition. When the appendix is pelvic and adherent to the bladder these symptoms may be prominent, but on the other hand symptoms referable to the loin will probably be absent. The X-ray is of great value in diagnosing small kidney or ureteral stones, and in connection with catheterization of the ureters in doubtful cases will positively determine the presence or absence of an obstruction in that canal.

Toxic nephritis accompanying appendicitis and obscuring the diagnosis has been found. In rare instances also a direct communication between an inflamed appendix and the pelvis of the kidney or ureter may bring the urinary phenomena into the foreground in a manner apt to mislead us.

I have operated upon a patient whose urine contained pus and epithelium from the pelvis of the ureter. There was present swelling in the right loin, and tenderness which extended in the direction of the attachment of the appendix; and the history of the three cardinal symptoms of appendicitis was elicited. The right iliac fossa was opened. The appendix, which pointed north, was post-colic and contained pus. It was adherent to and in communication with, the pelvis of the ureter (kidney), through which the contents of the appendix were being emptied into the bladder, thus explaining the urinary symptoms. The recovery was uneventful. Bevan reports a case where sharp pain in the lower abdomen was followed by a microscopic amount of blood in the urine; a diagnosis of renal colic was made, but when, a few days later, an abscess formed around the appendix, this organ was removed and proved to be the true seat of the disease.

FLOATING KIDNEY WITH A TWISTED URETER.

Floating kidney with a twisted pedicle may cause abdominal pain, nausea, vomiting, and chills and fever, which symptoms may suggest appendicitis. This condition may be diagnosticated from appendicitis by pain which radiates in the line of the ureter and is not increased to any marked degree by pressure; a history of a

movable tumor prior to the attack; the presence of blood in the urine; and absence of the cardinal symptoms of appendicitis.

In the absence of urinary symptoms abscess of the kidney, particularly if it be a floating kidney, necessarily presents greater difficulty in differentiation. In the latter instance, however, the tumor will be movable. I have operated on a case of acute suppuration of the kidney in which the urine was normal and the diagnosis was made on the anatomical situation of the swelling, in the absence of the characteristic symptoms of appendicular inflammation.

PERINEPHRIC ABSCESS.

When the appendix holds a retro-colic position or occupies the ileo-cæcal or subcæcal fossa, and inflammation of the organ has progressed to the formation of pus, the collection may be mistaken for a perinephric abscess. The presence of intestinal disturbance and of the cardinal symptoms of appendicitis, however, should be sufficient to justify a diagnosis of appendicitis. When the appendicular abscess is in relation with the right kidney, an incision through the loin, such as is made for the evacuation of a perinephric collection, may be followed by the discharge of purulent matter. It must be borne in mind, however, that the evacuation of a supposed perinephric abscess in this manner does not prove that the collection of pus was not in reality of appendicular origin. A case in point is the following:

The original diagnosis was appendicitis, and on account of the desperate condition of the patient, an incision for the evacuation of the collection was made through the loin. Recovery, with repair of the wound followed. The patient, however, was unable to resume his occupation on account of localized pain, referred to and above the posterior half of the crest of the ilium. Six weeks after recovery from the operation for the evacuation of the abscess he was again referred to me. Upon examination the incision was found intact, but tender. Upon palpation of the tender point distinct resistance was noted. Removal of the appendix was recommended. When the patient was under the anæsthetic and was being placed upon the operating table, a distinct fæcal odor, which was thought to be due to a bowel movement, was noticed. Upon the removal of the antiseptic dressing which covered the proposed field of operation it was found that the cicatrix had broken down at one point and that fæcal matter was escaping from it. Believing this to be a fæcal fistula, the result of

an original attack of appendicitis, I opened the abdomen, isolated the field of operation by gauze packing, and located the appendix. The tip of the organ was perforated and its lumen was found to be in direct communication with the faecal fistula. The appendix was removed and the wound was treated in the usual manner. I have treated other cases of like character.

Suppuration at the internal abdominal ring may closely simulate acute appendicitis. The existence of urethritis or epididymitis, the usual absence of vomiting and intestinal symptoms, and the location of the pain and tenderness may suffice to differentiate the condition.

EXTRA-UTERINE PREGNANCY.

The history of cases of extra-uterine pregnancy is usually that of partial or complete cessation of the menstrual flow for one, two or more periods, generally accompanied by other symptoms of pregnancy, and collapse supervening upon an attack of acute abdominal pain. The pain is long continued and paroxysmal, but not of the nature of intestinal colic. An irregular, bloody, vaginal discharge, generally lighter in color than the normal menstrual flow, and containing shreds of tissue—portions of the decidua—is present. Vaginal examination reveals a tender and sensitive mass in Douglas's *cul-de-sac*, unless the pregnancy be an abdominal one. In the majority of these cases there is a history of sterility for five or six years previous to the abnormal conception. If rupture should occur and the resulting hæmatocele become infected the diagnosis is rendered more difficult, unless the patient can give a clear description of the character of the pain and the collapse at the time of rupture. In a robust individual the anæmia and weakness would be more marked than in appendiceal disease.

In the case of pelvic hæmatocele consequent on ruptured extra-uterine pregnancy becoming infected the interval between the rupture and the infection will necessarily be longer than that between the onset of the attack of appendicitis and the formation of pus. It is very important here, as in all cases, to elicit a most careful history.

When the product of conception occupies the fimbriated extremity of the right tube, the points of differentiation are more difficult, owing to the close proximity of the lesion to the appendix, and the negative result of examination per vaginam prior to rupture. Should the two conditions occur coincidentally, it will be well nigh

impossible to differentiate between them. The chief points to be borne in mind, however, are the history, the absence of inflammatory symptoms prior to the rupture of the extra-uterine sac, and the presence of inflammatory symptoms in appendicitis. Appendicitis complicated by normal pregnancy in its early stages has been mistaken for extra-uterine pregnancy, yet the normal birth of a child within a reasonably short time previous, and the absence of decidual discharge from the vagina, should incline the diagnosis to appendicitis.

DISEASES OF THE FEMALE PELVIC ORGANS.

Various organic and functional abnormalities of the female genital organs give rise at times to errors in the diagnosis of appendicitis.

The **functional disturbances** are those associated with painful menstruation and the menopause.

Dysmenorrhœa may be mistaken for appendicitis or *vice versa*. An inquiry into the history of the case and careful examination will leave but little doubt as to the diagnosis. Pelvic examinations should not be neglected. McRae has called attention to the frequency with which painful menstruation obscures appendicitis, and is of the opinion that many such patients would be cured by the removal of their appendices.

Menopause.—During this period the gastric disturbances with the associated hysterical and neurasthenic manifestations may give rise to symptoms suggestive of appendicitis, but hardly to such an extent as to lead us to this mistaken diagnosis.

Acute salpingitis is very similar in its symptoms to appendicitis, especially if it be confined to the right side. The history of an infection aids us when it is positive, its absence means nothing. The disease differs, however, in its mode of onset. The pain and rigidity are low down, the latter not so early or so marked as in acute appendicitis. The gastro-intestinal symptoms, vomiting, etc., are as a rule absent. The most tender point, as in all affections of the uterine appendages, is just above the middle of Poupert's ligament, while in appendicitis it is in the right iliac fossa. Vaginal examination is of great aid. The tenderness in the right vaginal fornix need, however, not necessarily be due to an inflam-

mation of the adnexa, but may be caused by an acutely inflamed appendix placed in the pelvis. The relation of the tender point to the uterus will, however, enable us in most instances to determine definitely whether it arises from the tube and ovary or the appendix. When vaginal examination is negative as to the presence of a tender or congested area salpingitis may be excluded. It must be remembered that it is not very infrequent for the tube and ovary to become adherent to the appendix as a result of appendicitis.

PYO-SALPINX AND OVARIAN ABSCESS.

The presence in the recto-uterine *cul-de-sac*, in intimate relation with the uterus, of an inflammatory mass which renders the uterus partly or completely immovable, and which can be clearly outlined by vaginal, bimanual, or combined vaginal and rectal examination, together with a history of a vagino-uterine infection, especially gonorrhœa, and the presence of a septic fever, establishes the diagnosis of pyo-salpinx or of tubo-ovarian or ovarian abscess. Still, an inflamed appendix directed into the pelvis, and lying in relation with or adherent to the right tube and ovary, will simulate pyo-salpinx or tubo-ovarian or ovarian abscess of the right side in that there will be an inflammatory mass near the uterus, and pain and tenderness upon vaginal or rectal examination, or both. The diagnosis of appendicitis will be established if there can be obtained a history of previous attacks, characterized by a sudden onset of abdominal pain, usually becoming localized in the right iliac fossa, and rigidity of the abdominal wall. Tenderness in the right iliac fossa is present in both diseases, but in appendicitis the tender area occupies the higher position.

OÖPHORITIS.

Inflammation of the right ovary may be confounded with appendicitis, as it is attended with pain, tenderness in the right iliac fossa, nausea and fever. It is always, however, accompanied by disturbances of the uterine functions, and is demonstrated by vaginal or bimanual examination. The pain in appendicitis is at first in the peri-umbilical or epigastric region, and becomes localized

in the right iliac fossa. The tender area in appendicitis is situated in the iliac fossa, further to the right than in inflammation of the ovary, whereas in the ovarian affection the tenderness is never so intense as in appendicitis, and is not accompanied by a perceptibly enlarged appendix.

SUPPURATING OVARIAN CYST.

An appendicular abscess and a suppurating ovarian cyst on the right side present some symptoms in common which may give rise to difficulties in diagnosis. There are found a painful tumor in the right iliac fossa, which may be made out by vaginal, bimanual, and external examinations; vague symptoms of septicæmia; hectic temperature; and a history of previous gastric and urinary irritation. By careful consideration, however, the differences are sufficiently marked. In ovarian cyst the onset is gradual, and a history of some infection can generally be elicited. The pain is constant and dull in character; by pressure the significant "ovarian pain," which differs from the colicky appendicular paroxysms, may be produced, the rigidity of the abdominal walls is not so marked as in appendicitis, while the tumor itself is more elastic, less firmly fixed, and apparently has thinner walls and a more regular outline. If the abscess be of appendicular origin, there usually will be a history of one of more attacks which presented the characteristic symptoms of appendicitis, while if ovarian these will be absent.

OVARIAN CYST WITH TWISTED PEDICLE.

An ovarian cyst with a twisted pedicle gives, at times, a history of a slowly growing tumor, but is so frequently unaccompanied by pain that its presence is often unsuspected until the accident occurs. The onset of the acute symptoms of a cyst with a twisted pedicle is sudden, and is usually caused by an excessive peristalsis of the intestines or by sudden change of the position of the body, causing the tumor to rotate on its pedicle. A migrated daughter cyst becoming attached to the omentum in the neighborhood of the cæcum, has, on its pedicle becoming twisted, very closely simulated appendicitis (Brewer). If the twisting be complete enough

to shut off the circulation, the walls of the cyst quickly become gangrenous, and the patient's condition rapidly grows profoundly septic, while the localized peritonitis soon becomes generalized. Here again is seen a resemblance to an attack of appendicitis with abscess formation; but the difference in the shape and the elasticity of the swelling, the slow growth preceding the sudden onset, the difference in the character of the pain and tenderness, and the more general rigidity of the abdominal wall should enable one to distinguish between these affections. If, however, for any reason it be impossible to make a differential diagnosis, I would advise that at operation the lateral incision be the one chosen, because appendicitis is so much more common an affection that the chances are in favor of its being the cause of the symptoms. The median incision for appendicitis is illogical, unwise, and will in many instances hinder, if not entirely prevent, the proper treatment of the appendix. Even through the ordinary incision the removal of an adherent appendix from behind the cæcum may be extremely difficult; and through a median incision it often will be impossible. These difficulties are generally increased when there is pus formation, and under such circumstances any other than the lateral incision usually multiplies the danger of peritoneal infection.

Torsion of the omentum when it occurs acutely may give rise to pain, vomiting and extreme tenderness accompanied by the formation of a mass. If this be in the neighborhood of the appendix it is difficult to escape diagnosis of appendicitis with periappendicular involvement. In general the systemic symptoms of infection and toxæmia are less marked than in appendicitis though after gangrene has set in, which may occur early, fever and leucocytosis occur just as in appendicitis.

PNEUMONIA AND PLEURITIS.

The onset in these two diseases is sometimes very acute, and the pain in the side may be so severe as to cause rigidity of the abdominal muscles on the side affected. If this be the right, the diagnosis is sometimes quite difficult, especially in children, who are unable to describe their pain accurately. In pneumonia, however, the predisposing cause is more often exposure to inclem-

ent weather, a preliminary chill is frequent, vomiting is less usual, there is cough, and the pain is probably never limited to the abdomen; while in appendicitis there has usually been some indigestible food eaten, a chill is very unusual, vomiting is the rule, and the pain is generally umbilical at first, later settling to the right iliac fossa. There is seldom in appendicitis any thoracic pain, nor a cough. Physical examination will usually clear up any doubt by the revelation of the pathognomonic subcrepitant râle at the end of inspiration in pneumonia, or by the friction sound in pleurisy. In pulmonary disease the abdominal rigidity is easily overcome and the tenderness is not marked, if palpation be done with the palm of the hand rather than the finger tips. Guinou insists upon this means of differentiating the two affections, having found that deep but gentle pressure with the palm of the hand caused a cessation of the pain at McBurney's point if the affection was thoracic.

Brewer has recorded the case of a patient who, having had several attacks of appendicitis, complained, when recovering from a pneumonia, of sudden pain "in the right inguinal region." Symptoms of general peritonitis followed; the precarious condition of the patient forbade any operation. At the autopsy not a trace of abdominal inflammation was found, but cultures from the heart and spleen, showing the pneumococcus, proved it to be a case of pneumococcic septicæmia.

INTUSSUSCEPTION OF THE APPENDIX.

The causes of this affection, like those of intussusception in general, are very obscure. In some cases, notably Rolleston's, a concretion within the appendix has seemed to excite such violent peristalsis as to cause prolapse of part or all of the appendix into the cæcum. In Rolleston's patient, who died from perforation of a duodenal ulcer, without operation, only the mucous membrane of the appendix was found prolapsed into the cæcum, a coprolith being impacted in its orifice. It is of course probable that when partial inversion has occurred the protruding portion acts as a polyp does in irritating the rectum or the uterus, or like an elongated uvula, as suggested by Corner, in irritating the pharynx to renewed contractions. In no case were there evidences of previous attacks of appen-

dititis. Indeed, as remarked by Battle and Corner, it seems reasonable to suppose that previous attacks of inflammation would have rendered the appendix less liable to become intussuscepted, both by the stiff and unyielding condition of its walls thus induced, and by the production of peri-appendicular adhesions. Abnormal length of the mesentery and the ascending meso-colon is considered by some a predisposing cause of appendicular intussusception. Two patients had tuberculous disease of the peritoneum.

The treatment, therefore, to be advised for these cases, consists of laparotomy and gentle attempts at reduction, and if these fail, of excision of the appendix and so much of the cæcum and ileum as shall be found to be irreducible. The appendix should always be removed, to prevent a recurrence of the trouble.

FIG. 13.

CASE OF DR. THOMAS R. NEILSON.—INVAGINATION OF APPENDIX.—G. B., a little girl of five years of age, admitted to St. Christopher's Hospital, under Dr. Neilson's care, December 26, 1903. Four days previously the child had been attacked with severe abdominal pain causing her to crouch down on the floor, scream, double up and hold her abdomen tightly with her hands. This attack was followed by pallor, and the child seemed greatly fatigued. On the night of the 25th the attacks became more frequent, recurring at short intervals. There was no nausea or vomiting at any time; the bowels moved very frequently, the stools being small. Examination revealed only very slight rigidity of the lower segment of the right rectus muscle; there was no tympany; there was slight tenderness in the region of the appendix.

Dr. Neilson's diagnosis, accordingly, was chronic appendicitis with adhesions.

Operation by Dr. Neilson January 1, 1904: The appendix was found invaginated into itself and into the cæcum for upwards of one inch. There was no evidence of any other pathological condition thereabouts. The drawing on the opposite page accurately illustrates the condition found. The mucosa of the cæcum surrounding the intussusception was markedly congested.

An attempt was made first to draw out the intussuscepted portion of the appendix, but this failed, and accordingly the whole mass was excised from the cæcum and the opening closed by ordinary methods.

The child made a complete and uneventful recovery.

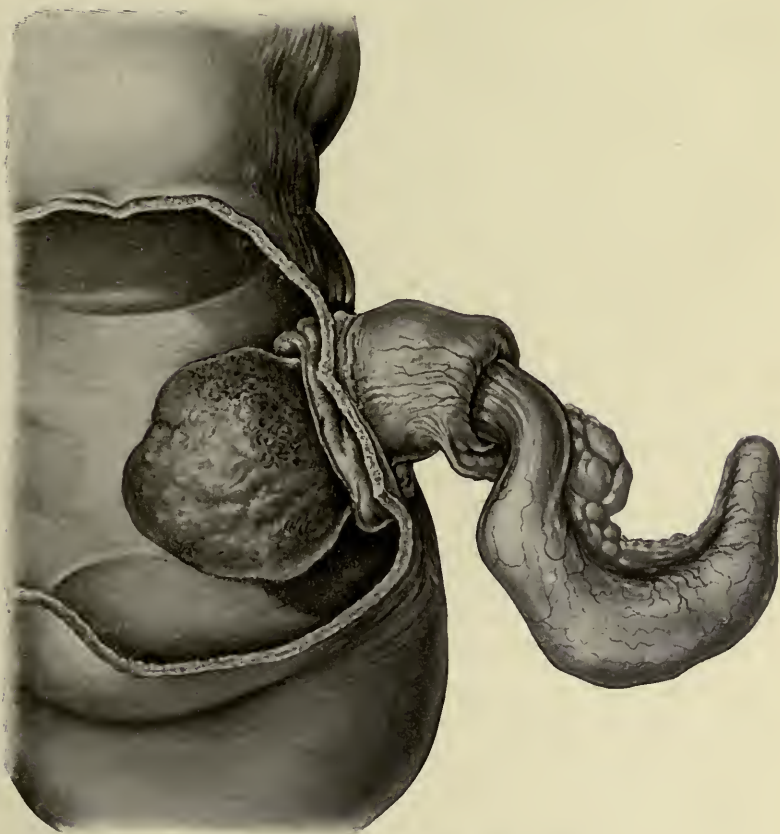


FIG. 13.—INTUSSUSCEPTION OF THE APPENDIX.
From a patient under the care of Dr. Neilson.

THE BLOOD IN APPENDICITIS.

Appendicitis shares with other acute infections the property of causing an increase in the number of leucocytes in the circulating blood. This characteristic gives in some cases material aid in diagnosis where the question is between appendicitis and some other painful abdominal condition which is not commonly accompanied by leucocytosis, as examples of which may be mentioned movable kidney, stone in the ureter, and typhoid fever.

The standard which we have chosen as the normal number of leucocytes is 7500 per cubic millimetre. Variations need not be given much weight either as a leucocytosis or as a leucopenia until the number rises above 10,000 or falls below 5000. Roughly speaking also, the degree of rise in the white cells is proportionate to the absorption into the systemic circulation of the toxins generated by the infection. Formerly there was a disposition to make this property an index of the severity of the appendicular disease and therefore of the necessity for immediate operation. The fallacy of this attempt has been demonstrated by increasing experience and is due largely to two reasons. (1) Infection of sudden overwhelming severity may be accompanied by no rise in the leucocyte count. At times there may even be a diminution (leucopenia). The reason for this appears to be the fact that leucocytosis is an expression not only of infection but also of the resistance of the individual attacked. When the patient is overwhelmed the function of leucocyte production shares in the general depression and the white cells which appear in the circulating blood are withdrawn into the immediate vicinity of the infection with equal or greater rapidity than they can be produced. Fortunately this state of affairs is not common, yet it is seen sufficiently often to compel attention. Usually the patient thus affected is one who has been weakened by age, excesses or chronic disease.

(2) The absorption of toxins does not in many instances run parallel with the appendiceal lesion. It is not uncommon to find the leucocytosis in acute catarrhal or interstitial appendicitis run

higher than when the organ has become completely gangrenous. This is not surprising when we consider that in gangrene of the appendix the efferent veins and lymphatics may be completely thrombosed thus cutting off the infected area from the general circulation. This failure of the toxins to be absorbed is probably responsible also for the well-known clinical observation that the temperature is apt to be but little elevated when the appendix undergoes gangrene. Not only is it true that the more severe manifestations of the disease may give lower leucocyte counts but the same variety of appendicitis so far as its clinical course is concerned may give greatly varying degrees of leucocytosis as the appended table shows at a glance. It is more than probable that different types of infection will exercise greatly differing powers of chemotaxis upon which the leucocytic response depends. There has been no attempt made to correlate leucocytosis with the type of appendiceal infection, and even were the laws governing it known to us it would be of no practical value from a prognostic standpoint since it is manifestly impossible to determine the nature of the infection without operation and then only after an interval required by the bacteriological technic.

Chronic appendicitis unless in the presence of a more or less acute exacerbation does not disturb the absolute or relative number of the leucocytes.

The variability of the leucocyte count and the elusive nature of the factors which control it are such as to make the estimation of the leucocytes a very unreliable guide in both diagnosis and prognosis. It is by no means a cardinal symptom to be considered with the diagnostic triad of pain, vomiting and local tenderness. When used as a guide for treatment too much reliance in it can result only in catastrophe. If it be used as a subsidiary aid and its limitations understood it is of value and should be obtained as routinely as the history and physical examination, but I must emphasize the statement that operation must never be undertaken nor deferred on the basis of the leucocyte count alone.

Differential Leucocyte Count.—During the last few years the importance of the differential count has been urged by some as of value in supplementing the information obtained from the simple estimation of the number of cells. This consists in the determina-

tion of the percentages of the various kinds of leucocytes as seen in the appropriately stained preparation. It is well known that the leucocytosis which is due to pyogenic infections is accompanied by a greater relative increase of the polymorphonuclear neutrophilic leucocytes than of the other varieties of leucocytes. Normally the polymorphonuclears comprise about 70 per cent. of the total number of leucocytes. These are the cells which are chiefly concerned in suppuration and as found in pus are known as pus corpuscles. Evidently the chemotactic power of pyogenic toxins is exerted more strongly upon these cells than upon the other white corpuscles of the blood. It has been claimed therefore that their behavior affords an index as to the severity of the infection. Stated in general terms the leucocyte count is an index of the resistance of the patient, the polymorphonuclear percentage indicates the severity of the toxæmia. In my clinic we have the differential count made as routinely as the simple count and have now more than a thousand observations of the behavior of the polymorphonuclear cells in acute and chronic appendicitis. In general I can corroborate the statement that a high proportion of polymorphonuclears is significant of a severe infection and when coupled with little or no rise in the absolute number of leucocytes it is a bad sign. Yet I have never decided for or against operation on the evidence of the leucocyte count alone and have frequently seen satisfactory recoveries in cases that showed from 90 to 96 per cent. of polymorphonuclears. Murphy quotes Albrecht's views on the differential count as coinciding with his opinions and his conclusions are those which I also have reached. Murphy says "The percentage of polynuclear cells is an indication of the severity of the infection, but not the degree of destruction. A high percentage does not denote a bad prognosis, so long as the absolute number of white cells is correspondingly high. A fall in the absolute number of polynuclears with a coincident decrease of the total percentage of leucocytes shows a decline in the infection."

Such a conservative estimate of the value of the differential count is more nearly correct than the emphasis laid upon it by Noehren who considers the estimation of the polymorphonuclears alone as of greater importance than the absolute white cell count or the relation between the two. He also attempts to use the poly-

morphonuclear count as an indication for or against operation, a misuse of a minor diagnostic sign which is pernicious, dangerous and which I unhesitatingly condemn.

Gibson lays stress on the disproportionate rise of the polymorphonuclear percentage as compared with the leucocyte count itself and considers this as indicating the gravity of the lesion. In many cases this is true, but it is not infallible. A rise in the polymorphonuclear percentage with a stationary leucocyte count, in the presence of other symptoms of continued infection may be an additional sign of the gravity of the lesion.

To Determine the Extent of the Lesion.—The blood count is especially deceptive when it is used in an endeavor to determine the extent of intra- or extra-appendicular involvement. In a very broad way the leucocyte count, in a patient previously well and of good resistance, may be said to indicate by its grade the severity of the disease when taken in conjunction with the clinical symptoms. Thus, a moderate count of 10-15,000 is the usual accompaniment of an ordinary catarrhal or interstitial appendicitis while higher counts indicate more acute changes or a rapidly developing peritoneal involvement. There are so many varying factors, however, in this—the patient's resistance, the kind of infection, the previous condition of the appendix and its anatomical relations—that it is best to consider it but very slightly in determining the extent of the inflammatory process. Manifestly it can give us no information regarding the imminence of gangrene or perforation which are the paramount issues. I have seen very mild grades of appendicitis give high initial leucocytosis, and the reverse also holds good. Finally, decision as to the advisability of operation in this disease in which time is such a precious consideration should never be delayed for successive leucocyte counts or differential estimations since the surgeon will soon find that the relationship of the laboratory findings to the clinical necessities is so variable that in the very cases where he most needs help there it will be too often lacking. There can be no objection to following the leucocytes in the cases that are not suitable for immediate operation but in these cases also it will be found that the proper moment for operation is to be determined by other considerations than the leucocytes.

The appended table will show according to groups the actual

initial count in my last 1018 cases of acute appendicitis in which a blood count was made.

Leucocytes	Catarrhal	Purulent	Gan- grenous	Localized abscess	Slight free fluid	Diffuse and general d. g.
5,000-10,000....	153	44	10	67	11	15 15
10,000-15,000....	105	50	23	120	31	38 15
15,000-25,000....	46	28	31	108	30	36 8
25,000 and over..	2	5	2	12	6	4 3
	306	127	66	307	78	93 41

	Up to 10,000	10,000- 15,000	15,000- 25,000	25,000 and plus	Totals
Catarrhal.....	153	105	46	2	306
Purulent.....	44	50	28	5	127
Gangrene.....	10	23	31	2	66
Localized abscess.....	67	120	108	12	307
Slight free fluid.....	11	31	30	6	78
Diffuse and general..(d)	15	38	36	4	93
(g)	15	15	8	3	41

To Determine the Prognosis.—The salient feature of the value of the blood count in prognosis is the fact that a low count in the presence of grave symptoms and evidences of peritonitis is a danger signal. This combination of symptoms might possibly lead us to delay operation in a given case, trusting to the patient's recuperative powers under proper medical treatment rather than risking surgical intervention when the resistance is so far lowered. Other-

wise the leucocyte count is valueless in prognosis and entirely so as an indication for or against operation.

The iodine reaction is of no value in appendicitis. As a means of determining the presence of toxæmia it is inferior to the leucocyte count or a polymorphonuclear increase, with which it corresponds in significance and generally in occurrence. It is found in so many diseases and is so uncertain in technic that it has fallen into well-merited disrepute.

PROGNOSIS.

The prognosis in a given case of appendicitis has reference, first, to the attack from which the patient may at the moment be suffering, and, secondly, to the future health of the patient. There can be no question that under all circumstances appendicitis is a most serious disease. It resembles certain other diseases—typhoid fever, for instance—in that at the time of examination of the patient the local and general conditions may be such that the unwary would give a favorable prognosis, whereas the judicious and conservative physician or surgeon, from his knowledge of the morbid processes at work, states that the present condition of the patient is favorable, but at the same time frankly acknowledges his inability to foretell what may occur within the coming hour. An attack of typhoid fever may be pursuing a favorable course until, entirely unannounced, intestinal hæmorrhage or perforation occurs and completely alters the aspect of the case. Similarly, a patient suffering with appendicitis may be progressing favorably, when suddenly gangrene or perforation of the appendix or rupture of a circumscribed peri-appendicular abscess may occur, and his condition may become most serious.

With reference to the attack of appendicitis from which the patient may at the moment be suffering, it is doubtless true of appendicitis, as of other diseases, that a certain proportion of cases will do well and ultimately recover under any treatment dictated by reason and the requirements of hygiene. It is claimed that from 80 to 90 per cent. of all cases will recover under medicinal, as opposed to surgical, treatment. But too frequently I have seen patients who were apparently recovering, or who were accounted as having already recovered, suddenly lapse into a critical condition, and sometimes die in spite of the most heroic measures to prolong their lives. The reason for this sudden change, and the possibility of its occurring at any moment, must be evident to all who have the slightest acquaintance with the pathology of appendicitis. The likelihood of the subsidence of the inflammatory phenomena in an appendix

and of the return of the organ to a healthy condition decreases, moreover, with the increase in the number and severity of the attacks. The reasons for this will be evident to those who read the chapter on the Pathology of the affection.

Specifically, the prognosis in many of the cases that are characterized clinically as mild, in which there is no demonstrable tumor, but little tenderness, and slight fever, and in which the lesions are probably catarrhal or a minor grade of interstitial alterations, is good with reference to the subsequent health of the patient. The prognosis with reference to the recovery from the attacks is good only with the important reservations that it becomes progressively worse with each succeeding attack, and that we are unable to state at what moment the pathological alterations may become much aggravated, and perforation or gangrene of the appendix ensue. Then it must also be borne in mind that relatively mild clinical manifestations may be associated with serious anatomical lesions, and that from the presence of the former we are not warranted in assuming the absence of the latter. The prognosis as to recovery from the attack is good, particularly in those of this class of cases in which a rapid amelioration of symptoms follows the institution of rational medical treatment. These cases often terminate favorably without recourse to operative measures, but the appendix remains in a diseased condition, and is liable at any time to develop most acute exacerbations of inflammation, with all their attendant dangers. The general health of the patient, moreover, cannot be considered a reliable guide in the question of prognosis; the robust and healthy are quite as liable to develop unfavorable symptoms as are the weakly and ill-developed. But age and sex have some bearing upon prognosis, although their importance is often exaggerated; children and females have in my experience been more fortunate in recovering from appendicitis than have adult males.

Those cases that present evidences of suppuration or cellular infiltration are next in severity to those characterized clinically as mild cases, where no tumor can be detected. These cases with demonstrable tumor, marked tenderness and rigidity of the abdominal muscles are always most grave; and the careful physician or surgeon is always most cautious in his prognosis where such symptoms exist.

In most of these cases we are warranted in assuming the presence of pus, but we are unable to state whether the appendix is perforated or gangrenous, whether rupture of a peri-appendicular abscess into the general peritoneal cavity or into the intestine or other intra-abdominal organ is imminent, or whether erosion and necrosis, or thrombosis of one of the iliac vessels is developing, etc. Such is the serious import of these conditions, concerning which we can state nothing definitely, that the prognosis, under such circumstances, is at most a mere hazard.

Such being the condition of affairs, it is evident that the prognosis in a given case of appendicitis depends more upon the form of treatment instituted at the onset than upon any other factor. If the appendix be skillfully removed within twenty-four hours from the commencement of the attack, the prognosis is favorable, and recovery will ensue in all but the most exceptional cases. As will be seen in the chapter on the Treatment of appendicitis, the mortality from this disease itself, before peritoneal complications have developed is, when treated by removal of the appendix, less than 1 per cent. This gives therefore a very much better prognosis both as to immediate and as to ultimate recovery than does any other form of treatment. It is, however, undeniable that a few cases will recover from their first acute attack without operation, and that a small percentage of these few cases may have no return of symptoms. As has been repeatedly urged in these pages, the surgeon cannot usually tell from the symptoms whether a case is progressing favorably or not; and in those apparently mild cases where it seems evident that the progress is favorable, he cannot be sure that perforation or gangrene will not occur without warning in the course of the next hour or two. This uncertainty is particularly present in cases where the opium treatment is adopted. Such is the apparent amelioration of symptoms that follows the use of this drug that the surgeon is often led to infer that the progress of the disease has been checked or that recovery has resulted. In many of these patients, however, despite the abeyance of symptoms, the disease is steadily progressing, and the physician's attention is finally attracted to the serious condition of the partly narcotized patient by the distended and tympanitic abdomen, the "leaky" skin, and the rapid, irregular and weak pulse.

The prognosis is materially influenced by the conditions found at operation. These are discussed at considerable length in the chapter on the Complications and Sequels of Appendicitis, under the heading of Complications of the Operation.

If the appendix is but slightly altered, and there is only a small amount of serous or sero-fibrinous exudate about the appendix, the outlook is most favorable. Patients with such conditions should not die; and it will be found that deaths following an operation undertaken at this stage of the disease are as a rule due to some extraneous and independent cause, such as croupous pneumonia, pulmonary or cerebral embolism, or other unavoidable disease.

If there is a circumscribed peri-appendicular abscess, shut off from the general peritoneal cavity by a firm fibrinous exudate, no matter whether the appendix be perforated or gangrenous, the prognosis, with certain reservations, is good. These reservations have reference to the kind of treatment adopted prior to the operation, to the condition of the patient at the time of operation, to the care practised in the administration of the anæsthetic, to the skill exercised in the operative manipulations, to the thoroughness with which all purulent foci are evacuated, together with the preservation of the general peritoneal cavity from infection; to the presence in the patient of other diseases, such as tuberculosis, heart disease, nephritis, etc.; to the character of the drainage established and that of the after-treatment adopted. If before the operation the patient has been either weakened through excessive purgation, or narcotized with opiates, his general condition at the time of operation will usually be such that the outlook is grave. Where heart disease or nephritis is present the operative risk is naturally much increased, not alone from the conditions surrounding the appendix, but from the anæsthetic as well; and where tuberculosis is present, even if no active abdominal form of the disease is noted, yet the tendency toward prolonged suppuration and at times the formation of a fæcal fistula is marked.

If there is a diffusing peritonitis of whatever variety, the outlook is ominous. Such conditions are sometimes found that it can be stated with positiveness that the patient will certainly succumb. In some rare cases the inflammatory process is of such a fulminating character that it may be impossible to secure the services of a

surgeon sufficiently early to prevent a fatal termination. In some cases it seems as if the fatal termination was inevitable from the outset, and that no matter how early or how skillfully an operation had been performed, it would not have availed to rescue the patient. Such cases are exceptional.

Presuming that a patient recovers from an attack of acute appendicitis, the prognosis with regard to his subsequent health varies with a number of circumstances. The chief factor to be considered is whether or not the appendix was removed at the primary attack. Even if it was removed it does not follow that the patient will necessarily be free from all further abdominal trouble. In cases operated on in the early stages, however, the likelihood of the formation of any adhesions sufficient to produce even the slightest discomfort is quite remote. When adhesions were already present at the time of operation, however, the case is very different. In my experience intestinal obstruction has occurred in nearly 2 per cent. of the cases, at some time or other after the operation. Where the appendix has not been removed during or immediately subsequent to the first attack, the prognosis is much more gloomy. Nearly 80 per cent. of my cases have had more than one attack of appendicitis, and while there are some cases in which each successive attack becomes milder in character, yet a large majority of patients sooner or later are compelled to undergo an operation, either because the constantly recurring attacks incapacitate them for work, or because suppuration, gangrene, perforation or general peritonitis finally supervenes. A few patients have a mild or even a moderately severe attack, recover, and never have any further symptoms. In general the milder the primary attack, the more is the likelihood of such being the case, but this is by no means an invariable rule. In the majority of cases recurrences sooner or later develop. Most of these occur within the first six months after the first attack; there are fewer within the succeeding six months; and the likelihood of recurrence decreases with each succeeding year. Occasionally, however, a recurrent attack is noted after an interval of fifteen or twenty years. Multiple recurrences are extremely common, and such is the natural course of the disease that it may be stated that an appendix once the seat of inflammation is prone to be again affected. As it is impossible to

presage either the time or the severity of the recurrence, a diseased appendix is a menace to life as well as to health as long as it remains in the body. If the danger from adhesions is present even after removal of an appendix during the first attack of the disease, it is evident that this danger is very much increased as long as the appendix remains in the abdomen. Adhesions to the parietal peritoneum, omentum, cæcum, colon, small intestine, bladder, pelvic organs, etc., may occur and give rise to a diversity of distressing symptoms, and these adhesions when firm and of long standing necessarily complicate the secondary operation and render the prognosis more unfavorable. In general it may be stated that the milder grades of appendicitis which subside with the formation of extensive adhesions exert more of an influence upon the prognosis than those cases of suppurative appendicitis in which the abscess ruptures spontaneously into the bowel or where the operation has been limited to the extra-peritoneal evacuation of such pus collection. The latter group of cases does not cause symptoms referable to the appendix region, nor do the lesions recur with nearly the same frequency as those with extensive adhesions. In some of these fulminating cases it is possible that the appendix is destroyed by the intensity of the primary inflammation, and that this fact explains the subsequent freedom from recurrence.

TREATMENT.

The treatment of both acute and chronic appendicitis includes, in its widest sense, the surgical treatment, such non-operative or medical treatment as may be given either preliminary to operation or throughout the course of the disease in the few cases not suited for operation and the proper hygiene of the patient between attacks, should he be allowed to have more than one attack. We should always bear in mind, however, that any form of treatment other than the surgical is to be considered only because extraneous conditions or certain definite contraindications, local or general, render it necessary to abandon or defer operative interference.

Acute appendicitis is the absolute domain of the surgeon. In America at least it is the consensus of opinion among both surgeons and internists that the diagnosis of the disease furnishes the indication for operation. Not any particular severity of the attack, grouping of symptoms, or special local signs need be looked for. Unless there are present one or more of the very few conditions which contraindicate operation it should be performed, and as a rule at the very earliest possible moment. It is essential that this should be appreciated fully by the general practitioner as it is he who as a rule first sees the patient and upon his advice operation is undertaken or deferred. It is but rarely that a patient will refuse operation if the facts and the dangers of delay are properly presented to him.

It has been abundantly demonstrated not only that no form of medical treatment yet devised can avert a fatal outcome in a considerable percentage of cases of acute appendicitis, but also that, granted a recovery from a single attack, no dietetic or hygienic regimen can guarantee against subsequent acute attacks in the majority of instances nor can it alleviate the various disturbances which are consequent upon the chronic form of appendicitis.

On the contrary all of these objects can be attained with a mortality that has actually reached the vanishing point *when the appendix is removed sufficiently early in the disease*. There is no

logical escape from the principle of immediate operation in acute appendicitis. This is not simply a reasoned conclusion but one based upon a personal experience now comprising many thousand cases. If it were in any way possible to determine which cases would recover and which get worse without operation, there might be some ground for declining to advise operation in every case. But such a distinction is entirely impossible. Cases apparently mild in onset, or with temporary remissions in symptoms are but too often just as dangerous as those apparently more severe. We have already spoken, in the chapter upon Symptomatology, of the practical impossibility of determining accurately the extent of the intra-appendiceal lesion by either the history of the attack or the physical examination. Nor will laboratory methods of investigation, such as the leucocyte count, be of any aid to us in this connection. This fact alone, that we are unable to prognosticate the course of acute appendicitis from its symptoms, should be sufficient to lead us to discard any method of treatment which seeks to dispense with operation. The only exceptions to the application of the rule of immediate operation are, first, the absence of a competent surgeon or lack of the essential requirements of successful surgery. There are few places in the civilized world to-day where this may be urged as a valid excuse. Secondly, the inability of the patient to endure any surgical procedure with a reasonable certainty of success. Such cases are *few* and depend upon the existence of a severe organic disease which would contraindicate surgical treatment of any kind. No one who is not identified with surgery should presume alone to pass upon such a matter. The obligation of the physician to secure a surgical opinion in these cases is equally great if not greater than in cases which are not thus complicated.

It is but a short time since a cardiac murmur was considered almost an absolute bar to operation. We now know that the true criterion of the ability of the heart to endure the strain of anæsthesia and operation is not its anatomical or pathological peculiarities but its functional capability. A heart which is not in a state of broken compensation can readily endure the short anæsthesia and slight trauma incident to the removal of the appendix by a skillful operator when complications are absent. In these cases there is even greater peril in delay. It cannot be too strongly urged that

cardiac murmurs, arrhythmia or hypertrophy are no bar to operation when the heart is able to carry on its circulatory function in a satisfactory manner. The same principle applies to renal and pulmonary complications. As a rule, also, it is possible for a skillful anaesthetist to give ether to these patients with safety. In a very few cases chloroform or nitrous oxide and oxygen may seem to possess an advantage and when general anaesthesia is considered out of the question we still have at our disposal intraspinal or one of the methods of local anaesthesia.

With the acceptance of the above principles, under ideal conditions there would be no need for further discussion of treatment except from the purely operative standpoint. Unfortunately owing to external conditions, to delay on the part of the patient or his physician, too often I regret to say the latter, or to an unusual variation or rapidity of the disease process we are obliged to consider what is often the most difficult aspect of the problem, namely:

The Time for Operation.—At the outset of this discussion we must insist that this is purely a question for the surgeon to decide. *There can be no qualification of the rule that the surgeon is to be summoned by the physician as soon as the diagnosis is made and the patient's consent obtained.* Within the first few hours the inflammatory process is as a rule confined to the appendix itself. Pathologically this may be considered the first stage of the disease. Clinically it is the optimum time and condition for operation and uniform success may be expected.

The second stage of acute appendicitis comprises those cases in which the inflammation has passed beyond the confines of the appendix itself and has involved the adjacent peritoneum in an inflammatory process which becomes either a localizing or a diffusing peritonitis. In the most favorable form of localizing peritonitis the appendix is quickly surrounded by fresh adhesions to the neighboring viscera, notably the omentum, without the formation of pus outside of the appendix, a condition which in respect to surgical prognosis is happily almost as favorable as that in which the process has not been allowed to progress beyond the appendix. The less favorable and more frequent form of localizing peritonitis results in peri-appendicular abscess. The diffusing variety of inflammation tends to progress to general peritonitis and death. It may, however.

be checked in its course and either undergo complete resolution or leave in its wake one or more residual abscesses which are not necessarily in the neighborhood of the appendix:

It is in connection with the diffusing type of peritonitis that it becomes necessary to decide whether or not immediate operation will necessarily be for the best interests of the patient. In acute appendicitis we may find very early a slight amount of fluid in the neighborhood of the appendix. Primarily in many cases the serous exudation from an inflamed appendix is sterile but in the stage here considered it contains bacteria and presents a cloudy, flaky or purulent appearance, and is frequently malodorous. While there is as yet no attempt at limitation of the process by cohesion of the adjacent coils of intestine or omentum, still the process in its extent is a limited one. The clinical signs of the disease are correspondingly confined to the location of the appendix. The patient also does not present the appearance of being desperately ill. The appendix may be acutely inflamed, or recently perforated or gangrenous. It is still the key to the situation. Remove it, prevent it from pouring out into the neighborhood additional infective material and the peritoneum will care for the local peritonitis unless the infecting agent be exceptionally virulent or the resistance unusually low. Success in these cases will be almost as uniform as in the cases where the disease is entirely intra-appendiceal. Thus far the treatment may be classed practically as ideal. Drainage will usually be unnecessary or at least may be limited in amount and brief in duration. The patient recovers rapidly, with few intra-abdominal adhesions, with little liability to complications and possesses a strong abdominal wall after healing has taken place. We may unhesitatingly lay down the rule, *That in every case of appendicitis seen early operation is indicated regardless of the mildness of the attack, and regardless of the severity of the attack.*

If the appendix is not removed within this early period of local disease and signs, we shall encounter an increasing number of cases with advanced progressing peritonitis who are evidently desperately sick. If the facies Hippocratica is not present in typical form it is at least foreshadowed. The pulse is rapid, soft and gaseous in character. The skin shows capillary stasis or a faint cyanosis. Later it may become leaky and pale. The temperature is usually as high

as 102° F., but may be normal. The respiration is moderately accelerated but inclines to be shallow and thoracic in type. On examination the whole abdomen is tense. Tenderness and spasm while usually most marked in the right iliac fossa, are not infrequently evident upon the left side as well and pressure over the upper abdomen is also resented. At first distention may not be noticeable though it soon becomes apparent. Peristalsis is retarded and brief and tinkling in character. There is no free passage of flatus or fæces. The leucocyte count is usually moderately high as is the percentage of polymorphonuclear leucocytes. The lower the leucocytosis and the higher the percentage of polymorphonuclears the more severe is the process as a rule.

In such a case we may expect to find upon opening the abdomen not only a diseased appendix but a widespreading peritonitis. The coils of intestine in the immediate neighborhood of the appendix may or may not show beginning cohesion. In any event it is evident that the peritoneal inflammation while taking its origin from the appendix is no longer dependent upon it for its existence. Indeed, the area of peritoneum in the neighborhood of the appendix is usually in the most favorable state of any area within the peritoneum so far as its systemic affect is concerned. Being the oldest focus of inflammation it shows the greatest deposit of lymph. The most effectual coffer-damming against infection and absorption has here been done. It is in the fresher area of the peritoneal cavity that the real conflict is being waged, that exudation of immune bodies and cells, and absorption of bacteria and toxins are most actively going on. The desperate state of the patient is the result chiefly of the struggle in these outlying portions and he stands or falls according to the outcome of this conflict.

As the disease which threatens the patient's life is now peritonitis so must the treatment be directed at that condition and any measure aimed at the appendix itself can find its justification only in the proof that the associated peritonitis with the systemic intoxication will be helped thereby. Any other course of reasoning is as illogical as to waste time trying to extinguish the match which set the house on fire. Will removal of the appendix relieve extensive diffuse peritonitis? The mortality records of any clinic which have to deal with this type of cases show conclusively that it will not. A

considerable number will still die of peritonitis. It could hardly be expected that a condition which no longer depends upon the presence of the appendix could be greatly benefited by its removal.

Can we at the time of removal of the appendix institute such other measures as more favorably to influence the associated diffusing peritoneal inflammation? From an experience covering the entire modern period of the development of the subject, and after a thorough trial of the surgical measures proposed for this purpose, including evisceration, irrigation with antiseptic or bland solutions, rough and gentle sponging, extensive and limited drainage with gauze and tubular drains, all of these procedures representing different epochs of advance, I am convinced that the less interference with diffuse peritonitis when at the height of its systemic effects, the better for the patient. By interference is meant not merely operative interference but medical interference as well. Many of these patients owe their desperate condition to the well meant but misdirected efforts of their physicians. More dangerous than the surgeon's scalpel is the harmless looking cathartic pill or purgative draught which is almost universally given in the early stages of this disease. The prevalence of this practice constitutes one of the greatest therapeutic follies of the day and it is not too much to say that the majority of cases of peritonitis resulting from appendicitis are instances of "therapeutic peritonitis" due to medical maltreatment.

An acutely inflamed appendix does not differ from any other inflamed member in its need for rest and protection. The stiffened overlying muscles, the shallow breathing, the protest against pressure and disinclination for food all proclaim this fact. Every effort of nature is set at naught by the violent peristalsis excited by purgation. The inflammation of the appendix itself is increased and when once it has been transmitted to the surrounding viscera the inflammatory products are distributed throughout the cavity by the writhing action of the intestines which at the same time prevents limitation of the process by cohesion of the coils. Surgeons are now awake to this danger and are urging the abandonment of purgatives and laxatives in the treatment not only of peritonitis but of any intestinal disease which is likely to give rise to it, chief of which is appendicitis. In my experience purgation and perforation are practically synonymous.

Both food and drink must be prohibited for the same reason. This fact is better known than the above and is more generally practised. There should be no relaxation from this rule. Even ice should not be given since a small amount of fluid in the stomach will excite peristalsis extending along the entire alimentary tube. The fact that fluids must reach the lower small and large intestine before they are absorbed makes clear the reason for this stringent rule. Not only does the peristaltic action of the intestines thus do harm after the ingestion of food or fluid but the organism rebels against the material introduced into the alimentary tract and vomiting is caused. The effect of constant vomiting, or even nausea in disturbing the rest of the peritoneum is only too evident. Not only may vomiting directly cause a spread of infectious material by stirring up the abdominal viscera but by its disturbing action upon the omentum it prevents this important structure from effectually surrounding the infected area.

Since it is so important to prevent peristalsis and vomiting, the necessity of lavage can at once be appreciated. We must not only see to it that no food enters the stomach, but it is of equal importance to relieve the stomach of whatever it contains. This should be done whether the patient has vomited profusely or is merely nauseated or regurgitating. After the patient has vomited freely if the stomach tube is passed it will be seen that the stomach has not been emptied. In other cases a large amount of foul fluid may accumulate in the stomach without causing more than slight nausea or regurgitation and at times there may be no symptoms at all of its presence. Hence the importance of using the stomach tube freely. Above all there should be no temporizing with gastric sedatives which have absolutely no place in the treatment of this condition. The mouth may be kept clean and moist by suitable washes or by damp gauze.

The sitting posture is essential in aiding the gravitation of infective fluid exudates from the diaphragmatic area where absorption is most active into the pelvis where absorption is least active and surgical treatment easiest and most promising should it become necessary to evacuate a purulent collection. One or two ice-bags upon the abdomen give comfort and aid in keeping the patient quiet and lastly but not least discourage meddling examinations which

tend to spread infection. The ice-bag should not be allowed to remain for any length of time in direct contact with the skin as serious necrosis may be caused. A towel folded about the bag will prevent this complication. The patient should not be permitted to believe that the comfort induced by the ice-bag is indicative of improvement in the disease any more than would be the case by morphia or a drug anodyne. An unfortunate notion has become current among the laity that appendicitis can be "frozen out." The profession alone is responsible for this idea and indirectly for the toll of deaths which are due to this mistaken practice.

The imperative need of water is satisfied by rectal instillation of normal salt solution which is best given by the continuous method of Murphy.

While it is true that the Murphy method is primarily intended for post-operative use and finds its greatest field of usefulness there, nevertheless, it is true that it is equally beneficial before operation.

In a patient who suffers from peritonitis the tissues are dehydrated. The splanchnic vessels are dilated, withdrawing a large amount of blood from the general circulation and fluids accumulate within the lumen of the intestine and in the abdominal cavity. The kidneys, since the blood does not reach them in normal volume and under normal pressure, fail to eliminate the poisonous products of infection. The heart is unable to functionate properly because of the lessened available volume of blood, and whatever toxins are absorbed by the tissues remain in more concentrated form because of the diminution in the bodily fluids as a whole.

By the use of continuous enteroclysis we are able to supply the much needed water to the body in quantities far in excess of that which can be satisfactorily introduced by any other method. In addition to its beneficial action in furnishing the depleted tissues and particularly the circulatory system with a sufficient quantity of fluid it exerts a directly beneficial effect upon the peritoneum itself. In post-operative cases drained by rubber dam, tube or gauze, where the Murphy method is used the drainage may be so profuse as to suggest direct transudation from the supersaturated tissues thus mechanically aiding in the removal of infective products and in a sense transforming the peritoneum from an absorbing to a secreting serous membrane.

The method of giving continuous saline enteroclysis is comparatively simple, but the fundamental principle must be correctly applied. The essential point is to introduce the fluid into the bowel under a pressure which is just sufficient to overcome the intra-abdominal pressure.

The fluid, kept at an even temperature of 110° F., is contained in a reservoir the base of which is but four to eight inches higher than the level of the rectal tube itself. The rectal tube, preferably the Murphy hard rubber tube, is connected with the container by a flexible rubber tube. The curved rectal tube is used for the sitting posture and the straight tube for the recumbent position. A tube with numerous small lateral openings is preferable to one with a single large opening since there is less danger of occlusion by faecal material. In children an ordinary self-retaining female urethral catheter introduced just beyond the internal sphincter will be found to work well and is somewhat less annoying to the small patient. The tube is introduced well into the rectum and the fluid allowed to run by gravity. There is not enough pressure forcibly to distend the bowel, but just enough to keep it well filled and continuously to renew that which is absorbed. Flatus easily passes out through the large tube.

Various methods, electrical and otherwise, have been devised for keeping the saline at an even temperature, but in the absence of these, the same result can be accomplished by constant watching of the solution itself and by the use of hot-water bags placed about the tube near the rectal end.

At no time should the saline flow rapidly. When this occurs the level of the top of the fluid must be lowered so as to reduce the pressure.

The amount of saline that can be absorbed when this method of administration is used is truly surprising. Adult patients very frequently will take as much as 500 c.c. (16 oz.) in three hours. The average patient will have no difficulty in taking 100 c.c. (3 oz.) per hour. Children average about 1800 c.c. (60 oz.) in twenty-four hours. In order, however, to accomplish the best results several points must be closely watched.

Distention which progressively increases is an indication that too much fluid is being injected, and calls for either a marked

lowering of the pressure of the fluid or a total cessation of the treatment for a longer or shorter interval. Per contra, failure to absorb the fluid calls for a slight increase in the elevation of the fluid in the container.

Puffiness of the eyes with œdema of the legs and the passage of excessive amounts of urine probably indicate that the patient is receiving and absorbing an excess of fluid and I regard these symptoms as an indication to lessen the administration of the saline. Occasionally the pressure of painful hæmorrhoids will not permit the retention of the rectal tube for a long period of time. In such cases the fluid may be given at regular intervals in quantities of 250 c.c. (8 oz.). Fortunately contraindications and unfavorable symptoms in the use of the continuous method are exceedingly rare. Failure to retain or absorb the fluid is almost without exception an evidence of improper methods of administration.

Alimentation is rarely a factor to be considered in the period during which the patient is deprived of food by mouth. It may at times seem advisable to add small quantities of expressed predigested beef juice to the saline infusion. Glucose may be used also in quantity to make 2 to 5 per cent. solution since this may be both absorbed and utilized as such by the body. The many complex formulas for nutrient enemas are worthless and as usually employed, rectal alimentation is merely a euphemism for absolute starvation.

Anodynes are rarely necessary and should be given only on the strongest indications, and then only in the smallest quantity. For pain and restlessness 1-20 gr. of morphia will usually prove sufficient. A sympathetic well-trained nurse is more efficient than opiates which cause distention and, there is reason to believe on experimental grounds, interfere with the activities of the leucocytes which are so important in defence.

If treated in this manner almost without exception, unless the patient be already moribund, the diffusing process will not only be checked but the peritoneal inflammation in the outlying areas will subside and localize about the region of the appendix. Coincidentally there is marked improvement in the facial expression, general appearance and feeling of the patient.

As the process localizes, at what time should we intervene? Should we wait until a sharply defined abscess has formed and

become firmly walled off? This method has strong advocates. It has nevertheless not been my practice and results justify me in speaking against it.

It is not possible to give any set time in days or hours when operation should be attempted since individual cases vary so greatly in their response to treatment. Success in inducing localization is attended by a marked decrease in tenderness and rigidity in the upper abdomen. Simultaneously, distention subsides in these areas. The patient becomes more comfortable. The pulse and temperature assume a more equable and lower level. Peristalsis is restored and there is a beginning of the free passage of gas and frequently faecal material. At the same time the local signs become more marked, and it is evident that the area of severe inflammation may be attacked directly without loss of time or the necessity for exploration. When this condition of affairs is present it is time to operate. Go quickly and directly to the focus. Deal with that and that alone. "The more thorough the operation, the more quickly the patient dies." Reach it by the so-called extra-peritoneal route if possible, making the incision far out toward the pelvic brim and working up under the inflammatory mass. If it is necessary to go into the general cavity, protect it well with moist gauze pads before treating the site of inflammation. Usually an abscess will be found. Mop away the pus and search for the appendix. It should be removed unless the search entails too great loss of time or the extensive breaking up of surrounding fresh adhesions. As a rule a tube should be passed into the pelvis to make sure that it contains no purulent collection. The proper disposal of drainage in accordance with the conditions and the closure of the wound except in so far as it is necessary to leave space for drainage to emerge, complete the operation. Results with this method have been so good as to make it preferable in my mind to waiting several days after localization for the production of firmer adhesions about the abscess. I have known abscesses to rupture into the general cavity while under observation and when this occurs it generally causes a virulent and fatal peritonitis. It is more difficult to secure the appendix when a large abscess has been allowed to form and experience has now shown that the appendix is but rarely completely destroyed by abscess formation and in a considerable percentage of cases gives subsequent trouble. Neither do

I look with favor upon permitting dense adhesions to form within the abdomen if it can be prevented. Convalescence is apt to be more protracted the larger the abscess, and the abdominal wall can never be so well approximated to avoid later hernia.

Treatment Between Attacks.

If a patient under purely medical treatment is so lucky as to recover from his first acute attack of appendicitis, it is in my opinion the duty of his attending physician to advise the removal of the offending organ as soon as his convalescence has passed. The appendicular inflammation has become chronic, and in nearly all cases the patient will be subject to recurring attacks, and not infrequently will be more or less of an invalid during the intervals. It must also be borne in mind that there are certain results of the inflammation that are not manifest to the patient, such as bands of peritoneal adhesions; that these may cause obstruction or chronic inflammation of the intestine, etc.; and that they may inaugurate their deleterious consequences at any moment.

Hence under no circumstances should any one who has once had an attack of appendicitis, and whose appendix has not been removed, ever consider himself safe from recurrence; and he should never deprive himself of the facilities for operative treatment, which may at any moment be imperatively demanded. To indulge the hope that the lumen of the appendix has become obliterated is, to say the least, worse than foolish.

To prevent recurrence of an attack, the patient positively refusing operation, he must live by rule, considering himself a semi-invalid. He should be cautioned to lead a regular, hygienic and abstemious life, and to avoid dietetic and other indiscretions.

Attention must be directed to the *clothing*, which should be changed to suit the varying conditions of the weather, and which should afford sufficient protection without exciting the skin to undue activity. The feet especially must be protected against the inclemencies of the weather. Only the simplest and most easily digested *food* should be eaten, and of a kind that will leave least residue in the intestinal tract. All coarse food, such as grits, coarse oat-meal, tough meats, etc., must be scrupulously avoided. Not only must

the food be selected with care, but it must be taken at regular intervals, and should always be eaten slowly, and be thoroughly masticated. There can be little doubt that the lunches of many business people—which usually consist of indigestible food, bolted without mastication, and at irregular hours—are a fruitful source of recurring attacks of appendicitis. The condition of the *teeth* must be ascertained and, if necessary, a set of false teeth should be procured. Regular action of the *bowels* must be insisted upon. This may best be accomplished by the cultivation of regular habits in this particular, whether there be an inclination to stool or not; by a diet carefully selected for this purpose, including various laxative fruits, raw or stewed, such as prunes, apples, and dates, or oranges, figs, etc.: There seems no reason to believe that the seeds of figs and other fruits lead to appendicitis. All purges should be avoided if possible, and attention should rather be directed to the treatment of the intestinal indigestion, which is usually the basis of the intractable constipation which is seen in some of these cases. If the constipation itself does not become the exciting cause of another attack of appendicitis, the use of cathartics and purges to overcome this constipation will be extremely apt to produce a recurrence; hence enemata are to be preferred whenever practicable. It must be borne in mind, however, that the intestinal indigestion which is present in these cases, and which is blamed for the chronic constipation, is not infrequently engendered or maintained by the associated appendicitis, and that relief cannot be expected under such circumstances until the offending appendix is excised.

It is barely possible that if any patient could be found who would be induced to lead a life of such exemplary regularity as is enjoined upon him, he might be free from further attacks of appendicitis for the rest of his life; but as such patients are the rare exception, it is not wonderful that from 75 to 80 per cent. of patients become subject to recurring attacks of greater or less severity. It is also the exception for the subsequent attacks to be milder than those which preceded; and when we consider the added difficulties in operation caused by the old adhesions, it is simply one more argument in favor of the removal of the appendix at the commencement of the first attack.

TECHNIC OF OPERATION.

Under this heading it is convenient to consider: (1) The preparation of the patient; (2) the details of the operation itself; and (3) the after-treatment. The treatment of the various complications and sequels of appendicitis is discussed in the final chapter.

Preparation of the Patient.—In acute cases of any severity the patient is usually in bed when first seen; but as already recommended, in no case should he be allowed to stay out of bed. In chronic cases the patient should be confined to bed for one or two days preceding the time set for operation, and his diet should be light and easily digested. Acute cases as already recommended receive nothing by mouth. It is impossible to sterilize the large intestine or the lower portion of the small intestines. It is worse than useless to employ drugs with this object. Restriction of bacterial activity and multiplication may, however, be effected by limiting the diet, particularly the proteid factor. Cooked foods are best as they are thereby sterilized and do not add to the ordinary intestinal flora. If the patient has not been seen some time before operation is performed it is useless to attempt any extensive sterilization of the mouth itself. In the case of pyorrhea this may be harmful by causing added irritation and increase of the gingival discharge. If there be sufficient time it is advisable to have the teeth and gums brought into a healthy condition. Ordinarily it suffices to have the patient wash the mouth frequently with a mild alkaline antiseptic solution and use a soft bristle or felt brush upon the teeth.

In the examination of the patient special attention should be paid to the heart, lungs and kidneys. In the presence of acute pulmonary complications, it may be necessary to defer operation. Chronic lung disease requires special consideration of the mode of anæsthesia to be employed. The heart, as has already been stated, should be regarded from the standpoint of its functional efficiency rather than with reference to the specific lesions. Should muscular weakness be suspected appropriate cardiac stimulants should be given prior to operation if time permits. Perhaps the most important of the preliminary examinations is the determination of renal sufficiency. Especially is this true of older individuals. The

specific gravity and the daily quantity are at once the simplest and best indexes of functional capacity. It is advisable also to make the ordinary chemical and microscopical examinations for the presence of abnormal constituents. If renal elimination is deficient steps should be taken to increase secretion, bearing in mind always that water is the best diuretic. In chronic cases water may be given freely by mouth, but in acute appendicitis it should be administered by rectum. Occasionally it may be beneficial to give it in the form of salt solution beneath the skin or into a vein, but this is rarely necessary or advantageous in preliminary treatment. It is best to question each patient as to the existence of an acute bronchial or nasal cold and if present to defer operation except in acute cases. In chronic cases the bowels should be evacuated by a laxative, preferably castor oil, the day before the operation and in every case an enema should precede the operation unless haste is necessary because of the acuteness of the disease. The thoroughness with which these preoperative conditions and others special to the cases may be followed out will depend in a degree upon the urgency of the condition. As a rule protracted pre-operative treatment is unwise as it has a bad effect upon the morale of the patient. In the ultra-acute cases the preparation of the patient practically resolves itself into preparation for the operation itself.

Where time and the constitutional condition of the patient permit, all demands of what may be called ordinary cleanliness should be met. That is to say the patient should receive a hot tub bath on the evening of the day before operation. An entire change of the personal clothing of the patient and of the bed linen should be made on the morning of operation. The entire abdomen and especially the pubic region should be scrubbed with tincture of green soap and all hair removed from these localities by shaving, after which a further and thorough scrubbing (using a piece of gauze or a soft brush) with soap and water should be made. After rinsing off the epithelial débris with sterile water the fatty and sebaceous materials are removed with alcohol. Harrington's solution is then briefly applied with a sponge and the skin again thoroughly flushed with a 1-1000 solution of bichloride of mercury. Dry sterile gauze should then be placed over the abdomen and secured in such a manner that it will not become displaced. It is assumed that the nurse

or other attendant who is entrusted with the preparation has not previously handled septic or infected materials and that the hands should be thoroughly cleansed and rubber gloves donned with the same scrupulous care that the surgeon himself must exercise.

When peritonitis or abscess is present the scrubbing should be exceedingly gentle to avoid rupture and the dissemination of infective products. When time is important this preparation may be carried out on the table after the administration of the anæsthetic has begun. If an interval of several hours has elapsed between the preparation and operation it is advisable to scrub the skin thoroughly with alcohol or Harrington's solution before starting the operation.

The above is the method of preparation which has given me great satisfaction. It is but fair to say that there are many variations of this procedure which give equally good results. The principle is cleanliness, it matters not how that is attained. The method of disinfection of the skin by alcoholic solutions of iodine has proved to be satisfactory if the necessary precautions are observed. The solution should be perfectly fresh and preferably not stronger than 5 per cent. The skin must be dry before it is applied; it should not be used in too great concentration as dermatitis and often blistering may result. Some individuals have an idiosyncrasy which makes them very susceptible to irritation of the skin by iodine.

In abdominal operations care should be taken not to permit the intestines coming in contact with the iodine-covered skin because of the danger of causing necrosis of the endothelium of the peritoneum.

The anæsthetic of choice in all abdominal work is ether given by the open drop method. It may with advantage be preceded by nitrous oxide. If nitrous oxide is employed in this way I have found that subsequent etherization is sometimes not so satisfactory as in cases where ether is given from the outset. In ordinary cases therefore simple etherization is preferable. In children and highly nervous patients the preliminary use of nitrous oxide is of distinct value in that it acts more quickly and lessens the psychic effect which may be equally as harmful as the operation itself. As time goes on I find fewer and fewer cases in which complications demand the substitution of one of the other modes of anæsthesia. Pneumonia, acute bronchitis and in general the acute pulmonary conditions

contraindicate etherization. In chronic bronchitis with copious secretion ether is more likely to be followed by pneumonia than is one of the other methods. In desperate cases upon whom the surgeon proposes to carry out some simple procedure, the exact limits of which he knows beforehand, such, for instance, as the incision of an abscess, I favor local anæsthesia or the use of nitrous oxide and oxygen. Spinal anæsthesia from personal experience and the literature I consider too dangerous for routine employment. Where a general anæsthetic is contraindicated and the operative difficulties are likely to be great it may be used. On account of its immediate dangers and remote toxic effects, the field of chloroform is becoming more and more restricted and it is probable that we can now dispense with it altogether as an anæsthetic for this type of work. If used, it should always be preceded by atropine to counteract its early inhibitory cardiac action to which sudden death may be due. Nitrous oxide and oxygen given simultaneously is the only active competitor of ether at present. The anæsthesia which is thus induced is less satisfactory for abdominal work than is ether anæsthesia and since the safety of the patient is so dependent upon a favorable condition for surgical work, or in other words upon the ease and rapidity with which the surgeon can carry out the required procedure, in my opinion ether is still preferable.

The most important thing in anæsthesia is to have a competent anæsthetist. In this country we have been tardy in recognizing and acting upon this fact. It is better to trust the more dangerous anæsthetic to an experienced anæsthetist than to have the safest administered by a tyro as is too frequently done. The anæsthetist has the life of the patient in his keeping no less than the surgeon. Unskillful administration may be responsible for death either directly or by hampering the surgeon in the successful performance of his manipulations. No one can be a good anæsthetist unless he or she has had considerable experience and is constantly doing this sort of work. The development of specialists in anæsthesia is therefore inevitable in all surgical centers and should be encouraged. In my clinic the anæsthesia is given by nurses specially trained for this work. The entrance of women into this field has seemed to me to be a step in advance, as it is comparatively easy to find a woman who will devote her whole time and attention to this one

branch. So far as adaptability is concerned, while it is true that not everyone is fitted to become a good anæsthetist I have found the women who are attracted to this work to be equally as satisfactory as men. It is unsafe to entrust anæsthesia to untrained internes.

The Operation.—There are in use several *incisions* through the abdominal wall, each of which has its advantages in certain cases. In any case, the incision should be in the right iliac region, and should aim to secure the readiest access to the appendix, the greatest facilities for drainage (when this is required), and the least

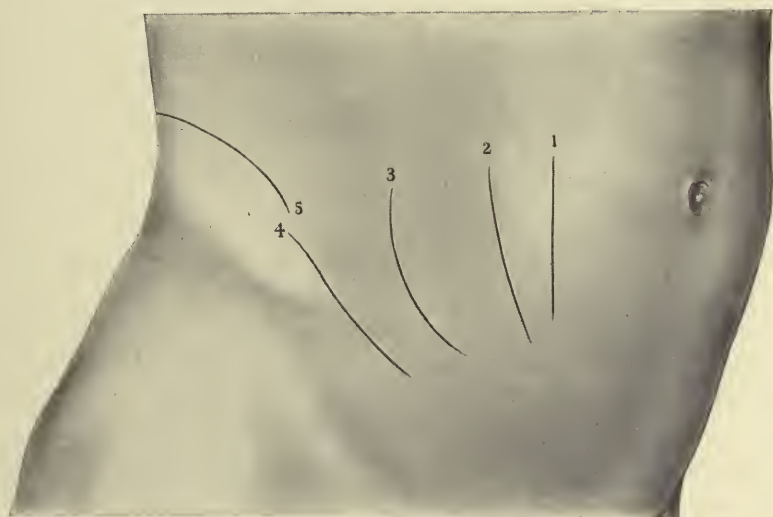


FIG. 14.—SKIN INCISIONS FOR APPENDICITIS.

1. The Simple incision through right rectus muscle. 2. Incision of Battle, Kammerer, and Jalaguier. 3. McBurney's incision. 4. Hancock's incision. 5. Oblique lumbar incision.

probability of subsequent hernia. The median incision for appendicitis cannot be too strongly condemned: it is not founded on good anatomical grounds, and is therefore irrational and dangerous, particularly if pus complicates the case.

Abdominal incisions may be classed as simple or direct and indirect. In the former variety all the layers of the abdominal wall are divided in the same plane, and in the latter these layers are divided in different planes, the lines of the incision crossing,

as in the McBurney incision, or being parallel but not coincident, as in the incision practised by Battle, Kammerer, and Jalaguier.

That incision which I usually employ, and prefer for all but the exceptional cases, is the simple incision passing through the outer half of the right rectus muscle. This incision is easy and rapid of execution, can be enlarged at will or made of insignificant size, affords ample drainage facilities, and is, I think, not more likely to result in hernia formation than any other incision. Often a small incision will be sufficient, yet those who have not had considerable experience in surgery should rather make the incision too large than too small. When adhesions or other complicating features are present the incision, if it be not already sufficiently large, should at once be made so lest injury be done the tissues in an attempt to operate through an opening which does not give full access to the area to be dealt with.

I frequently remove the appendix in clean cases through an incision in the peritoneum only long enough to admit the index-finger. The line of the deep epigastric vessels should be borne in mind, and the incision placed above it. They run in an approximately straight course from their origin from the external iliac vessels just above Poupart's ligament to the umbilicus. Hence the lower end of an incision of about two inches in length need not divide them. After dividing the skin and superficial fascia, the anterior sheath of the rectus is exposed. This consists of two layers, the aponeurosis of the external oblique muscle and the anterior layer of the aponeurosis of the internal oblique. By dividing these the fibres of the rectus muscle are exposed. These are then separated longitudinally with the handle of the scalpel and the posterior sheath of the rectus, the transversalis fascia and the preperitoneal fat are exposed. If the deep epigastric vessels come into view they may be pushed aside or if this is not possible they should be seized with two pairs of forceps, cut between and tied before proceeding with the operation. Nerves, so far as possible, should be displaced either upward or downward. Below the semilunar fold of Douglas the posterior sheath of the rectus is deficient—usually below a line from one-third to one-half the distance from the umbilicus to the symphysis pubis. Each layer of the abdominal wall should be divided to approximately the same

extent. When the structures lying beneath the rectus muscle are exposed, they should be caught in hæmostatic forceps at each side of the wound, and the surgeon should cautiously cut through them into the peritoneal cavity, with the belly, not the point, of the scalpel. As this is done traction should be made upon the two pairs of forceps, so as to raise the tissue away from the underlying intestine, and care should be exercised to cut only during the process of expiration, since during inspiration the intestines are forced against the parietal peritoneum. When the peritoneal cavity has been opened the scalpel is to be laid aside and the peritoneal wound enlarged with blunt-pointed scissors, the index-finger of either hand being used as a guide. In chronic cases a pair of dissecting forceps may now be introduced in the direction of the cæcum, which is grasped and brought out of the wound. It is recognized by its longitudinal bands, its size, by the absence of epiploic appendages and its pearly color. When the symptoms are moderately acute the surgeon should first take the precaution of introducing his index-finger and palpating the site of the appendix to determine the existence of a mass or adhesions. Under these conditions the wound should at once be enlarged and no attempt made to deliver the appendix blindly. In the presence of pus or whenever the attack is very severe the incision should be made long enough primarily to give a view of the region of the appendix. In conditions so severe as this, however, it will usually be preferable to make the incision external to the rectus to afford more direct access. It has been objected to the simple rectus incision that it divides the abdominal nerves and hence by relaxing the rectus muscle predisposes to the formation of a hernia. When the fascias are correctly approximated, however, this does not occur as hernia formation is determined to a much greater extent by defects in the fascia than by muscular atrophy. Moreover, if ordinary care is used in small incisions it is rarely necessary to injure the nerves.

Another somewhat similar incision is that proposed nearly simultaneously by Battle, by Jalaguier and by Kammerer. The anterior sheath of the rectus is exposed and opened, as in the previous incision, but a little closer to the semilunar line. Here its two layers are quite distinct. The rectus muscle is then separated from the outer portion of its sheath and is drawn toward the median

line, its fibres not being separated as in the incision first described, the surgeon working around its external border. Its posterior sheath, the transversalis fascia, preperitoneal fat, and peritoneum are then opened well toward the median line of the muscle—midway between the linea semilunaris and the linea alba. By this means the incisions through the different layers of the abdominal wall are not superposed one directly on the other. This incision is not adapted for pus cases, because of its valve-like formation, but when completely sutured offers a very good protection against hernia formation.

The McBurney, muscle-splitting or gridiron incision is placed entirely external to the semilunar line, dividing the oblique and transverse abdominal muscles in the line of their fibres. The skin incision may be made in any desired direction, preferably in the line of the fibres of the external oblique. The aponeurosis of this muscle is then exposed, nicked with the knife, seized with two pairs of forceps and torn in the direction of its fibres, exposing the fibres of the internal oblique beneath its delicate overlying fascia which in this situation run nearly transversely. This muscle and the transversalis (with its delicate overlying fascia) are then likewise separated in the direction of their respective fibres, exposing the transversalis fascia, preperitoneal fat and peritoneum. These structures are then divided with the usual precautions, in the line of the external oblique fibres. A wound thus made does not divide any of the abdominal nerves, which fact is evidently a strong recommendation in favor of such an operation; but the great difficulty is to select the proper case. Although it is understood that this operation is particularly intended for the interval cases, yet many of these are quite complicated, and many require enlargement of the incision. This is best accomplished by making a second cut upward along the semilunar line from the inner angle of the McBurney incision. I seldom use this incision in the case of females since it is always advisable to palpate the internal genitalia and if, as occasionally happens, a condition requiring operation is found it is more difficult to enlarge the McBurney incision for satisfactory pelvic work. Usually it will be better to close the McBurney opening and make a separate rectus incision.

An incision similar to that originally employed by Hancock, is a good one in abscess cases, where the mass is close to the anterior

superior iliac spine or where the appendix can be distinctly located in this position. This incision is in the line of the fibres of the external oblique, about half an inch above the outer extremity of Poupart's ligament. There are divided, the skin, superficial fascia, aponeurosis of the external oblique, a thin layer of fascia covering the internal oblique, the internal oblique, branches of the deep circumflex iliac vessels, a second thin layer of fascia overlying the transversalis muscle, and the transversalis muscle; the cut edges of the muscle on the inner side of the wound are then well retracted, and the transversalis fascia preperitoneal fat and peritoneum are divided well down to the outer side of the cæcum. This incision is particularly adapted to those cases of appendiceal abscess where the patient is in no fit condition to withstand a complete operation, and where drainage of the abscess is all that is desired. In such cases it is frequently impossible to recognize the various layers of the abdominal wall, since they are frequently infiltrated and matted together. Where the appendix, however, is found well toward the crest of the ilium it can be readily removed through this incision, with little danger of infecting the peritoneal cavity, as the limiting adhesions constituting the inner wall of the abscess cavity, are not broken down. The division of the fibres of the internal oblique and transversalis muscles which is necessitated by this incision, renders the subsequent formation of a ventral hernia more likely when drainage is employed, but this is a small matter compared with the recovery of the patient, which is much more apt to follow the use of an incision allowing of rapid completion of the operation and direct drainage. This is an incision which I never employ unless we have every evidence that there is a well-localized abscess and that the incision will enable the operator to reach it extra-peritoneally.

Still another incision is occasionally useful. This is an *oblique incision* passing from above the iliac spine back into the loin space, in the direction of the fibres of the external oblique. It is particularly adapted to suppurative cases in which the appendix lies to the outer side of the cæcum and colon, running northwest; by this incision better access is gained to the site of the infected appendix, and there is less likelihood of infecting the general peritoneum. The great difficulty, however, in all these cases, is to determine, before the

abdomen is opened, just where the appendix lies; and unless there is pretty good evidence of its running northwest in the right lumbar region it will not be advisable to employ this incision, although Hancock's incision, just described, may often be extended upward into this oblique incision with the utmost advantage. When drainage is used the development of ventral hernia is to be anticipated, and a secondary operation will frequently be required for its cure.

In making any of these incisions, hæmorrhage should be checked before the peritoneum is opened. Unless some vessel large enough to have a name—such as the deep epigastric or circumflex iliac—be divided, it is at times sufficient to clamp the bleeding point for a few minutes, when the bleeding will be found to have been arrested. It is always safer, however, to ligate every bleeding point.

It will be convenient first to describe the method to be employed in removing the appendix in cases where pus is known to be absent, and subsequently to describe the treatment of suppurative cases.

Technic in Clean Cases.—The surgeon may either pull forth the presenting bowel, which is usually the cæcum, through the wound, and trace one of its longitudinal bands down to the base of the appendix, whose position is thus determined; or, if his skill and tactile sense be sufficient for the purpose, he may introduce one or two fingers into the wound, isolate the appendix between them, and withdraw it from the abdomen at once, without first locating the cæcum. The latter makes a very brilliant operation, but the former plan is less apt to miscarry. In trying to find the appendix by the sense of touch, the best manœuvre is to locate the external iliac artery, which is readily found by its pulsation, and then to run the finger up along its course until it is arrested by the lower end of the mesentery and the cæcum, in which neighborhood the appendix may usually be found; by hooking the finger around it, it may then be delivered from the abdomen. My own practice in clean cases is not to retract the margins of the wound when the peritoneal cavity has been opened, but to introduce the index-finger and locate the cæcum by the sense of touch, when, with a pair of dissecting forceps which are passed along the finger to the cæcum, it is grasped carefully and drawn into the wound. It is then grasped with the finger and thumb, and delivered through the abdominal wound until the base of the appendix is seen. If the wound is small and the cæcum large,

care should be taken not to deliver too much of the cæcum at one time, but to replace some before delivering more. If this matter is not attended to at the proper time, the surgeon may be mortified to find, after removing the appendix, that he must enlarge the abdominal wound to enable him to reduce the cæcum, which soon becomes congested when constricted by a small wound. I have seen one case in which efforts to reduce the cæcum through too small a wound caused the separation of the ligature from the meso-appendix, with the result that the patient nearly lost her life from intraperitoneal hæmorrhage before the accident was discovered by the constitutional symptoms of concealed hæmorrhage. Where the great omentum or terminal coils of small intestine interfere with the free delivery of the cæcum and appendix it is my practice to introduce one or more gauze pads and in this manner make the manipulation easier and less likely in the presence of infection to damage the surrounding healthy peritoneum. If the cæcum and appendix do not lift out easily, in other words, are bound down by adhesions, I at once enlarge the wound as it is not safe to make traction to any degree, for fear that adhesions may be torn and infection liberated. There is also risk of tearing a subcæcal vein by too much traction upon the cæcum, an accident that has occurred once in my own practice and which necessitated a secondary operation for the resulting hæmorrhage.

When the appendix is delivered a hæmostatic forceps should be placed upon its base and one upon the mesentery near the tip. Now lifting the appendix by the forceps the mesentery is spread out and may be perforated in a bloodless space near the base of the appendix by a hæmostat carrying a fine silk or chromic catgut suture. The hæmostat is withdrawn and the meso-appendix ligated. Now releasing the hæmostat originally applied to the tip of the mesentery the surgeon grasps the appendix with dissecting forceps and cuts the mesentery along its appendiceal attachment freeing the appendix to its base. A catgut suture is tied around the appendix about one-fourth inch distal to the junction of the appendix with the cæcum. A purse-string suture of fine Pagenstecher linen thread is then placed in the sero-muscular coat of the cæcum around the base of the appendix and at a distance of about one-half inch. This is allowed to lie while the surgeon picks up the appendix by the suture

on its base, which has been left long for this purpose. A piece of gauze is placed around the appendix to guard further against contamination of the field of operation. With a pair of scissors curved on the flat the appendix is now amputated between the forceps and the ligature and quickly removed; the mucous membrane of the appendix is excised and the stump charred with the cautery. It is better technic to amputate the appendix with the cautery. If no cautery is at hand it will suffice to touch the stump with pure carbolic acid and then with alcohol, the excess of which should be absorbed by a gauze sponge. By cultures made from stumps treated in both ways I have found that the actual cautery is the surest means of sterilization. Now discarding the gauze which has been used to protect the field, an assistant grasps the stump with a pair of dissecting forceps and the surgeon takes up the ends of the purse-string suture. The long ends of the appendix ligature are cut near the knot, the stump of the appendix is invaginated into the cæcum and the purse-string is tied, completing the removal of the appendix. It should be borne in mind that each instrument that is used to touch the cut surface or stump should be discarded at once. Always survey the ligature on the meso-appendix at the completion of the operation before closing the abdomen. Being assured that hæmostasis is complete the cæcum is repositioned and the wound closed as hereafter described.

Certain variations from this simple technic may be rendered necessary by conditions. When the meso-appendix is especially large and fat it is safer to ligate it in sections. When the meso-appendix is absent or the appendix tied down by adhesions it is necessary to free it first, clamping the bleeding points as they appear and ligating later. If the meso-appendix be short and distorted it may be clamped in sections and the appendix freed little by little. The clamps should be tied off before removal of the appendix to avoid displacement and also the dissemination of infection if contamination should accidentally occur during the treatment of the stump.

Occasionally we find an appendix so bound down by adhesions at its tip that only the base can be delivered. In these cases the base must be tied off as described and the appendix dissected free from base to tip, bleeding vessels being clamped and ligated as cut.

When any part of the appendix lies beneath the serosa of the cæcum, as is sometimes the case, the bowel should, when possible, have its serous covering restored by means of Lembert sutures in order to lessen the probability of the formation of adhesions.

Various modifications of the treatment of the stump are in use. A few surgeons drop the stump with or without treatment after disinfection. I condemn this practice as I have seen intestinal obstruction from a band proceeding from a stump replaced in this manner. Dawbarn's method of simple invagination into the cæcum without ligation I have abandoned after having several cases of bleeding more or less severe from the cut surface. Complete excision of the base of the appendix and repair of the resulting hole in the cæcum is unnecessary and more likely to cause contamination of the peritoneum and the abdominal wound. The various sutures in use for covering over the stump are not worth discussion since they possess in common the principle of burying the stump in order to leave no raw surface to invite the formation of adhesions.

Technic in Suppurative Cases.—Since the success of the operative treatment of appendicitis complicated by pus formation depends largely upon a knowledge of the anatomical varieties of peri-appendicular abscess, as well as upon a complete comprehension of the safest method of evacuating the pus and removing the appendix without infecting the general peritoneal cavity, a brief description of the operative technic to be practised in each instance may be given.

Depending upon the location of the pus, peri-appendicular abscess is met with as one of five varieties: First, and in my experience the most common, is that in which the collection lies below or to the outer side of the cæcum beneath the anterior parietal peritoneum, being confined by the cæcum, coils of small intestine, the omentum, the parietal peritoneum, and inflammatory exudate; second, that in which the collection of pus is located behind the cæcum, to the outer side of or behind the cæcum and ascending colon, or between the layers of the ascending meso-colon, in the retro-peritoneal cellular tissue; third, that in which the abscess lies in the pelvis, being usually entirely shut off from the general peritoneal cavity; fourth, that in which the collection of pus is located near the median line of the abdomen and to the median side of the

cæcum; fifth, that in which the pus is free in the general peritoneal cavity.

In dealing with any variety of circumscribed peri-appendicular suppuration, it is important to protect the general peritoneal cavity from infection. As a rule it is only when the abscess is of the first variety described above, that it can be reached and evacuated without first traversing the free peritoneal cavity. Only a few cases of the second variety can be treated in this manner. Hence it becomes necessary in almost all suppurative cases to work through a cofferdam of gauze. The correct disposition of this gauze requires the utmost skill. It may be laid down as a rule that in endeavoring to exclude the intestines from the field of operation the disposition of the gauze must be commenced from the extremities of the wound, and proceed to the centre; by placing a gauze pack first in the centre of the wound, the intestines will prolapse around both sides of it, thus increasing the difficulty of excluding them from the operative area. Another good rule is never to proceed with an operation in which adhesions are discovered until gauze has been so disposed as to protect the general peritoneal cavity from the rupture of an abscess which may be concealed by adhesions. The gauze should not be carried into the peritoneal cavity further than is necessary and its introduction should be accomplished with great gentleness and care to avoid as far as possible injury to the endothelium which predisposes not only to infection but to the formation of adhesions.

In dealing with any variety of peri-appendicular suppuration which must be treated transperitoneally, as soon as the peritoneum is incised the general peritoneal cavity should be protected from infection by the proper disposition of gauze pads. The first pad to be introduced should pass from the right iliac fossa into the pelvis, and will hold the small bowel away from the lower angle of the wound. Then as many more pads as may be required are to be placed from below upward until the entire median side of the wound, as well as its lower extremity, is lined with gauze. Finally, the upper limit of the field of operation must be protected by gauze. The abscess should then be opened by breaking through the layer of exudate that forms its outer wall, or, if the abscess be of the second variety, through the outer layer of the ascending meso-colon. The abscess cavity should be wiped out with dry gauze. The appendix

should then be located and removed. When the appendix is gangrenous or involved in the abscess the stump should not be invaginated into the cæcum but after ligation with chromicized catgut it should be sterilized with the cautery or carbolic acid and alcohol and dropped back without any attempt to bury it. The catgut is less liable to form a dead ligature than silk or other non-absorbable material. Drainage of the abscess cavity is essential. If it has not been necessary to enter the general abdominal cavity it will suffice to insert a rubber tube of large calibre, or strip of folded rubber dam or wisps of gauze. In fact any device which will maintain a free avenue of discharge through the wound and avoid all damming back of the exudation will prove satisfactory. Gauze should never be packed tightly into the cavity, and if used alone should be cautiously loosened on the second or third day to make sure that it is not acting as a plug. It is more satisfactory in most cases to use a rubber tube either alone or in conjunction with gauze. When the abscess is not of large size folded strips of rubber dam are a most excellent form of drainage as they provide for the free exit of the secretions and at the same time permit more rapid collapse and obliteration of the cavity.

When the general peritoneal cavity has been opened, in addition to draining the infected area it becomes necessary to wall off the adjacent intestines and omentum. Nothing will accomplish this so satisfactorily as gauze. In all my work I use plain moist sterile gauze since it answers every purpose and is unattended by any of the disagreeable or dangerous features of gauze impregnated with iodoform or other antiseptic agent. The purpose of gauze in this instance is not only to provide capillary drainage but to provoke adhesions between the adjacent viscera, thus establishing a tract shut off from the peritoneal cavity and placing the bottom of the abscess in free communication with the surface. On account of the danger attendant upon the formation of intestinal adhesions it should be our aim not to excite denser or more numerous adhesions than are necessary. An excess of gauze therefore should not be used and often it will be possible to interpose between it and the healthy intestines a surrounding layer of rubber dam which has less tendency to excite excessive granulations upon the surface of the bowels. This also facilitates removal of the gauze in addition to

making it less painful. This is the principle of the familiar "cigarette" drain, which, as usually made, is too small to accomplish drainage and is inefficient in establishing a drainage tract. When the septic focus is very small and the exudation slight, in other words when there is but little to drain the cigarette drain will be satisfactory. When the cavity is large, foul, its walls rough and friable and it is evident that drainage must be free, a rubber tube should always be used and this may with advantage be placed in the centre of the nest of gauze reaching to the bottom of the abscess cavity. It should be fixed to the skin by a fine suture.

In practically all suppurative cases I pass a glass tube into the pelvis and aspirate to determine whether a purulent collection is present. If so the tube is allowed to remain. Also, when it is feared from the nature of the case that the pelvic cavity has been or is likely to be contaminated from the manipulation in the arrangement of the drainage I consider it a precautionary measure to leave a tube in the pelvis, which may be removed in twenty-four or thirty-six hours if the fluid aspirated therefrom is scanty, clear and straw colored. I do not allow a glass tube to remain longer than thirty-six hours being influenced by the assertion that they are more likely to cause necrosis of the bowel or acute angulation resulting in obstruction than tubes of rubber, though my personal experience with glass drainage does not bear this out. If the character of the drainage indicates that it is unwise to discontinue the drain a small rubber tube may be passed down the lumen of the glass tube and the latter withdrawn.

The drains should emerge, as a rule, through that part of the wound nearest the abscess cavity; usually this will be through the lower extremity of the abdominal opening. In some cases the wound should be left entirely open; usually it may be closed in part. If an oblique incision passing into the flank has been employed the drainage should emerge from its outer or posterior extremity. After the lapse of four or five days, or even longer, the drainage may be removed, only enough being replaced to insure drainage and the abdominal wound allowed to heal gradually by granulation. A fuller discussion of the subsequent management of these cases will be found under the heading of After-treatment.

In the treatment of the first variety of peri-appendicular abscess,

the collection of pus is often opened immediately upon carrying the incision through the parietal peritoneum. It is for these cases that I prefer the incision close to the iliac crest and Poupart's ligament, since the abscess usually points in this situation. I am opposed to the practice of opening abscesses transperitoneally when it is possible to open into them directly without exposing the general peritoneal cavity to infection. Certainly if nature has succeeded in localizing the inflammatory process to an isolated area, it must be considered rash surgery to open avenues of infection to the free peritoneum. Not every abscess is large enough or so favorably situated as to permit of extra-peritoneal attack. In these cases the risk of infecting the peritoneal cavity by the transperitoneal operation must be accepted and while the great majority of these cases recover, yet their convalescence is apt to be more stormy, the risk of obstruction greater, and occasionally general peritonitis ensues. The fact that most of these cases recover should not in my opinion inspire the surgeon with the belief that it is a safe procedure and one to be uniformly adopted in all cases of abscess. When a peri-appendicular abscess is large, well defined and abutting upon the parietes at a safe point of attack it should always be opened extra-peritoneally. Irrigation in this variety of abscess is attended by danger on account of the delicacy of the confining wall, which renders dissemination of infectious material a matter very easy of accomplishment. Evacuation of the abscess is ordinarily effected without risk of infecting the peritoneum, since the incision that corresponds to the most prominent part of the swelling, or, if no swelling be present, to the point over the involved region most tender to pressure, comes directly down upon the purulent collection. This variety of abscess can usually be said to be present when the abdominal muscles along the line of the incision are found to be the seat of inflammatory œdema and infiltration. If the muscles are not thus affected, the infiltrate will be found in the transversalis fascia and the preperitoneal fat. The pus is readily disposed of by mopping with pieces of gauze. If the can be located and removed with a minimum risk of spreading the infection it should be done.

In this first variety of abscess it frequently happens that the collection of pus is not confined at its lower end, but is in communica-

tion with the pelvis. I make it a rule, therefore, to pass a glass drainage tube down to the floor of the pelvis, to determine definitely the presence or absence of pus. On many occasions when operating upon this variety of peri-appendicular suppuration, I have evacuated no more than a dram or two of pus upon opening the peritoneum; but upon passing a drainage tube into the pelvis, as much as half a pint of pus has escaped.

The second variety of appendiceal abscess when it is large and evidently pointing in the loin may be attacked directly by a loin incision and evacuated extra-peritoneally in the same manner as is indicated for the first variety. At times the situation of the abscess cannot be determined clearly before the abdominal cavity has been opened. Even in such an event, in abscess of this variety I would prefer to close the anterior incision and drain through an extra-peritoneal incision in the loin. Extremely small and encapsulated abscesses in the subcæcal fossa will naturally be opened through an anterior incision, but abscesses of any size which have as their posterior wall the cellular tissues posterior and lateral to the cæcum or ascending colon should invariably be opened extra-peritoneally. The appendix often can be found and removed. It is seldom necessary to leave the appendix and every effort compatible with the general safety of the patient should be made to find it. I do not agree, however, with those surgeons who advise never to leave the appendix. In a certain small proportion of cases extensive damage may be done to the friable bowel by too active search and it is better judgment to desist and accept the chance of recurrence which is present when the organ has not been removed, or better, to remove the appendix at a second operation after healing has taken place. Drainage is established in accordance with the principles previously indicated.

In operating upon the third variety of peri-appendicular abscess the abdomen is usually opened by an incision in the right rectus, the inner margin of the wound raised by retractors and the general peritoneal cavity well walled off from the pelvic cavity with gauze before an attempt is made to treat the appendix or the abscess. The gauze is most readily disposed by carrying one or more pads across the intestines toward the left side and then successively packing gauze from this across the median line and then above the cæcum

on the right side. In this way the wall of pads isolates the general peritoneal cavity from the pelvis and not only gives additional room to work but prevents the extension of pus when the abscess is opened. After the proper disposition of gauze the finger should be carried over the brim of the true pelvis down into the collection of pus, and, with the finger as a guide, a glass drainage tube should be introduced. Through this the pus may be evacuated. The appendix may then be sought and removed. If the abscess is very small and accessible a glass or rubber tube may be the only drainage required. Usually it will be best to place round the tube one or more gauze drains in order to secure isolation of the healthy peritoneum from the abscess and drainage tract. The tube, if of glass, should be removed in thirty-six to forty-eight hours and a small one of rubber substituted. This may be withdrawn gradually depending on the amount of suppuration present. The gauze should not be tampered with for at least four days or more, when it may be gently loosened, but not withdrawn until it may be done without using undue force. The upper portion of the abdominal wound can usually be closed at the time of operation. The drainage tract must be allowed to heal by granulation.

If it were not possible to exclude so thoroughly the area of operation, it would no doubt be safer to evacuate the abscess through the vagina or the rectum, the case then being analogous to the treatment recommended for the second variety of peri-appendicular suppuration, by evacuation through the loin; with the important exception, however, that in the latter the appendix can frequently be successfully removed through the lumbar incision at the first operation, whereas in the case of pelvic abscess the appendix could not possibly be removed through the vagina or rectum. In selected cases in adults this method of evacuation will give good results. It should be attempted only when there are the most definite indications of a large pelvic collection which is pointing in the region of the rectum or cul-de-sac and the upper abdomen is entirely clear. Manifestly it is difficult to be certain of these conditions. In children the vagina should never be used to drain a pelvic abscess and the rectum is less available than in adults on account of its small calibre.

In the fourth variety of peri-appendicular abscess the collection of pus lies to the inner side of the cæcum, and the confining wall is

made up of the cæcum, appendix, small intestine, mesentery, omentum, and possibly the sigmoid flexure. At times, also, the purulent collection is found beneath the mesentery of the terminal portion of the small intestines. These cases are among the most fatal of all varieties of circumscribed peri-appendicular suppuration and the surgeon is indeed fortunate if he can open into the abscess cavity without first traversing the peritoneal cavity. If, however, on making his incision in the usual place, he finds adhesions to the parietal peritoneum and evidence of inflammation in a region which makes it probable that this form of abscess is present, it may be necessary for him to make a second incision toward the median line of the abdomen, to insure the proper disposition of gauze for the protection of the general peritoneal cavity. The further operative procedures are similar to those already detailed.

The treatment of the fifth variety of suppurative or diffuse purulent peritonitis has been discussed in part in connection with the question of the time for operation. When diffuse peritonitis is widespread as previously indicated operation should be deferred until localization has taken place. The operative treatment then becomes the same as detailed in the discussion of the several varieties of abscess. In the earlier stages of unconfined peritonitis, the treatment may consist solely in the removal of the appendix. The judgment and experience of the operator must be called upon to decide upon the necessity for drainage. We formerly drained too freely and have learned that the peritoneum can care for an amazing amount of infection without help. The majority of cases which show only turbid or slightly flaky fluid exudate may be closed completely with the assurance of recovery. When the pus is foul or vicious in appearance it is safer to insert a tube into the pelvis which may be removed in twenty-four to seventy-two hours depending upon the amount and character of the drainage which takes place.

Few cases of this variety will be encountered if the plan previously laid down for the treatment of diffusing peritonitis be followed, for in this way diffusing peritonitis is converted to circumscribed peritonitis. The early cases which show a free, more or less purulent, effusion in the neighborhood of the appendix or in the pelvis may or may not require drainage. If very turbid, flaky or foul a tube should be inserted into the pelvis to provide for drainage. But I drain

much less frequently than formerly in this class and whereas I once adopted the rule "when in doubt drain" I am now more inclined to advise "when in doubt do not drain."

If the appendix or its bed is gangrenous, or a weakened portion of bowel exists a wick of gauze or folded rubber dam should be placed in contact with this area and brought out through the wound. When free purulent exudate is present in the peritoneal cavity a glass tube should always be placed in the pelvis before the operation is concluded in order to test by aspiration and inspection the amount and character of the fluid which has gravitated into the pelvis. If it is decided not to drain this may at once be removed. In other respects the operative treatment of the early stages of diffuse peritonitis does not differ materially from the operation practised when the disease is confined entirely to the appendix. I have abandoned irrigation of the abdominal cavity with resulting reduction in mortality.

Not infrequently conditions are found in the abdomen which complicate the operation.

These circumstances may be due either to conditions existing before the appendix became inflamed, or to changes produced in the progress of the disease. Among those existing before the onset of the appendicitis, *unusual positions* of the appendix are the most important, often causing considerable difficulty in the removal of the organ. I have frequently encountered cases in which the anatomical conditions were such that at first sight the organ might be supposed absent. In these cases the appendix was usually found in intimate association with, and beneath the peritoneal covering of, the cæcum—the same layer of serous membrane being reflected over both (Fig. 8). Or the appendix may be partially or wholly intra-peritoneal, and yet escape detection because of its situation in the ileo-cæcal fossa, or in some other pocket of peritoneum around the caput coli. Again the appendix may have slipped into a hernial sac, and thus elude the surgeon. In all such cases the operator should first locate the cæcum, and then follow down one of its longitudinal bands, when these can be recognized, until the base of the appendix appears; it will then usually be possible to perceive the situation of the rest of the organ. Exceptionally neither the appendix nor cæcum can be found in the right iliac fossa; here

it is probable that the cæcum retains its foetal position high in the abdominal cavity, or even in the right or left hypochondriac region.

Various circumstances due to the inflammatory changes themselves often combine to conceal the appendix. Chief among these is the presence of *adhesions*, which, in long standing cases, may acquire such bulk and vascularity that the unwary operator may congratulate himself on having discovered the appendix when in reality he is dealing with neighboring bands of adhesions. If, in addition to the presence of bands of adhesions and perhaps pus, the appendix be subserous, the determination of the whereabouts of the organ is sometimes exceedingly difficult, and its removal is particularly arduous. Should such conditions exist it may be advisable to cut through the external layer of the ascending meso-colon in order to gain free access to the appendix. This procedure reduces to a minimum the danger of infection of the general peritoneal cavity.

The appendix is sometimes embedded in a great mass of fibrinous exudate. If this cannot be readily removed, its thickest and firmest portion, which usually corresponds to the seat of primary disease of the appendix, should be incised, whereupon the appendix will be readily detected. Again the appendix may be so rolled up in a fold of omentum that it is impossible to define its outline. In these cases it is proper to ligate and cut away the omentum along its attachment to the appendix, after which the appendix itself can usually be freed with facility. This method ensures control of hæmorrhage from the omentum and permits of ready manipulation of the appendix.

Sometimes, either because it is subserous, or because of adhesions, it is impossible to bring the tip of the appendix into the operative field. Under these circumstances it is sometimes possible, after ligating and dividing the base of the appendix, to strip it out of its peritoneal coat as a finger is pulled out of a glove; by thus removing all but the serous covering the entire area of infection is taken away, and the serous envelope cannot cause a recurrence of the disease. It is often much easier to ligate and divide the base of the appendix first, and subsequently to ligate its mesentery and detach the remainder of the organ; especially convenient is this procedure where the wound is deep and where the appendix runs in a northerly direction posterior to the cæcum. When once the base of the organ

is divided, and the first section of the mesentery ligated and cut, it will be found that the direction and location of the remainder of the organ can be very much more readily detected, and its removal accomplished without difficulty.

A very *fat meso-appendix*, unless properly treated, often complicates the removal of the appendix, especially by giving rise to troublesome hæmorrhage. A fat meso-appendix is always friable and it is likely to be torn during the operative manipulations attending the removal of the appendix, especially when the application of the ligatures is undertaken. It is best to ligate a fat meso-appendix in sections, and to cut away each portion as the ligatures are tightened. This procedure minimizes the danger of laceration and consequent hæmorrhage.

At times there is *necrosis or gangrene of the apex of the cæcum*. If such be the case, it will often be found that it is impossible to secure any tissue sufficiently healthy to retain sutures introduced for the purpose of closing the opening. An attempt, however, should be made to close it by the introduction into the cæcum, wide of the necrotic area, of sutures so placed as to include as healthy tissue as is possible. Too much tension on the sutures must be avoided; and it will often be found that mattress sutures hold better than the ordinary Lembert stitches. When the perforated or gangrenous area approaches too closely the ileo-cæcal valve, great care must be exercised to avoid encroaching too much upon this orifice; ordinarily, however, no fear of producing stenosis need be entertained. Whether the opening is sufficiently patulous can be determined by invaginating the ileum upon the tip of the finger through the ileo-cæcal valve. If any doubt exists as to its sufficiency an ileo-colostomy should be made at once. When the cæcum cannot be closed securely, the great omentum may be carried down to the area affected, and a portion of it made to serve as a flap, by stitching it in place so as to reinforce the sutured area; or if a large meso-appendix be present it may be utilized for the same purpose. I have frequently done this with good results. I have also employed Cargile membrane on numerous occasions, but much prefer an omental flap. In certain cases it will be found impossible to close the gangrenous area. All that can be done under such circumstances is to wall off the general peritoneal cavity by a coffer-dam of gauze and to leave the gangrenous

area *in situ*, but exposed beneath the wound. In a few days the slough will be cast, with the formation of a fæcal fistula, which may be closed at a subsequent operation, if repair does not take place spontaneously. In many of these cases the surgeon's ingenuity is taxed to the utmost, and the greater his experience the more likely are his endeavors to be attended by a successful outcome. It is well to bear in mind that if the gangrenous area be invaginated, and the abdominal wound be immediately closed, the development of a fatal peritonitis is a most likely event.

In a considerable number of cases the appendix is found *adherent* to one or another of the *abdominal* or *pelvic organs*. In these cases great care must be exercised in the removal of the appendix because of the liability of the occurrence of hæmorrhage, or the subsequent development of a fæcal fistula. Hæmorrhage is especially to be feared in those cases, fortunately rare, in which the appendix is discovered adherent to the iliac vessels. After detachment of the appendix the vessel itself must be carefully investigated, as in some cases it has been found to be the seat of necrosis or more or less gangrene. If such be the condition, and the weak point in the wall of the vein is not reinforced by peritoneal flaps, fatal secondary hæmorrhage may ensue. Where the appendix is adherent to the small intestine, the colon, or the sigmoid flexure, it is usually advisable to invert the point of its attachment to these structures with a few Lembert sutures: these serve to control any hæmorrhage from the point of contact, and lessen the likelihood of subsequent perforation.

SEQUELS OF THE OPERATION.

Unfavorable sequels of an operation for appendicitis are almost unknown when the operation has been performed within the first twenty-four or thirty-six hours of the disease. Almost every one of the serious and at times life threatening complications that follow an operation may be directly laid to procrastination in seeking the surgeon's knife.

In suppurative cases which have been operated upon with apparent success there may appear in a week or more after the operation one or more *secondary or residual abscesses*. In cases which have been subject to more or less widespread peritonitis for several days before operation, one or more small independent col-

lections of pus may be present at the time of operation and be overlooked unless the surgeon takes care to note the conditions present in areas adjacent to the immediate vicinity of the appendix where the major abscess is usually found. Particularly is this true of the pelvis. I have not infrequently found only a small amount of encapsulated pus about the appendix when the pelvis contained a large collection of pus. Less commonly smaller abscesses may be present beneath the mesentery at a distance, or enveloped in the omentum or loops of bowel. A subdiaphragmatic abscess also may co-exist. Apparent recovery from the operation may be followed by increase of symptoms due to enlargement of the overlooked abscesses. For this reason, unless I feel sure from the physical examination that a peri-appendicular abscess is single I do not perform the simple extra-peritoneal evacuation of the abscess but rather open into the free peritoneal cavity and explore the suspicious areas immediately adjacent, particularly the pelvis.

In other instances the collections of pus noted subsequent to operation are purely a secondary development which must be charged to defects of drainage. The difficulties of ideal drainage of the peritoneal cavity are too evident for anything more than comment. Fortunately it is usually possible to attain our object satisfactorily from the standpoint of results. In a series of 2400 cases forty-seven instances of secondary abscess were encountered. Of these thirty-four recovered and thirteen died.

Suspicion is aroused of the presence of a secondary abscess when the patient still shows the signs of infection and toxic absorption after the site of the primary operation is clean and healthy in appearance. The encapsulated focus is at times palpable through the abdominal wall or if in the pelvis it can be felt by rectum or vagina. Tenderness is usually present. Rigidity and spasm are less constant. Distention, which is not uncommon, masks the palpatory findings. When the collection is immediately beneath the diaphragm the signs and symptoms are those elsewhere detailed in connection with subdiaphragmatic abscess. Incision and drainage at the earliest moment is the only treatment that offers hope of recovery.

I have recently had under my care at the German Hospital a case of suppurative appendicitis where the appendix was removed and drainage instituted by the transperitoneal route. The wound granu-

lated satisfactorily, and the patient was discharged from the hospital, and returned to the dispensary to have the wound dressed. About two weeks subsequently a residual abscess formed, for which the patient was again admitted to the hospital. A large fluctuating abscess was pointing above the iliac spine. I opened this by direct incision, and evacuated a large quantity of offensive pus. For a couple of days the boy did well; but he then began to vomit, his fever became higher, his bowels were obstinately constipated, and it was evident that there was secondary peritoneal involvement. Recognizing that longer delay meant death, I opened his belly in the hypogastric region, turned out his intestines, which I found adherent in innumerable places, and separated all the adhesions. There were, I think, at least seven different abscesses among the intestinal coils, one abscess being beneath the transverse meso-colon in the epigastric region. Drainage was instituted by means of a glass tube to the pelvis and multiple wicks of gauze throughout the abdomen, and the wound of operation was partly closed. The lad's fever subsided, his stomach became retentive, and although multiple fæcal fistulas developed, he is now, I am happy to say, well.

At times in cases of suppurative appendicitis there may be found an **abscess in the omentum**, apparently entirely unconnected with the original focus of infection. Such an abscess is as a rule best treated by excision of the entire area of omentum involved in the process. If adhesions render this course impracticable, care should be taken to secure adequate drainage from the abscess cavity after evacuating its contents.

In certain of the suppurative and gangrenous cases of appendicitis, and particularly when the abscess or the appendix lies behind or to the outer side of the cæcum or colon, the **surrounding tissues** will be found **semigangrenous**. In this type of the disease the wound must be treated as an open one, no attempt being made to close it. I have seen partial or nearly complete closure followed by an extension of the inflammation to the neighboring bowels, resulting in paresis and distention, which, to the inexperienced, may simulate intestinal obstruction, and especially so if the patient is subject to paroxysmal pain due to gas.

When these wounds appear thoroughly healthy (filled with granulations) it is the practice of some to introduce sutures in the

hope that the subsequent tendency to hernia will be less. I regard this as a perfectly useless procedure; not only does it do no good, but it may result in harm by confining septic material in the wound. To satisfy oneself that this procedure is useless it is simply necessary to repair a few hernias following such cases. Immediately after division of the abdominal wall, in any case, there is retraction of the different layers, particularly of the aponeurosis of the external oblique muscle on the outer side of the wound, where it is least restricted in its movements; and nothing short of apposing layer to layer and maintaining the apposition will surely guard against hernia. It can readily be seen that this is not done even when through and through sutures alone are used for primary repair of the wound; and hence it is even less useful in sewing up a granulating wound.

Acute intestinal obstruction is a sequel which is really more due to the appendicitis itself than to the operation, but is more conveniently considered in this place. In my experience this serious complication occurred in 33 of 2400 cases, or 1.37 %. It may develop before any operation is performed, or its onset may be delayed for weeks, months, and in rare instances for years, after the acute affection. Its occurrence in connection with chronic appendicitis has already been discussed.

It is, of course, most likely to occur where generalized adhesions are present, and especially when the small bowel is involved. The cæcum, the colon, and the sigmoid flexure are relatively so immovable that obstruction of these parts of the intestinal tract is comparatively rare. It also seems that the presence of a faecal fistula, in cases where many adhesions were present at operation, renders the subsequent development of intestinal obstruction less liable to occur. Perhaps this is so because the drainage of the intestinal tract present in such cases keeps the small bowel fairly quiet, and by thus lessening peristalsis enables the inflamed bowels to recover with as few kinks and adhesions as possible. On the other hand the existence of obstruction below the seat of a faecal fistula necessarily keeps this from healing.

Post-operative obstruction may be one of three kinds:

1. Those following immediately after operation.
2. Those the result of septic peritonitis.
3. Those the result of mechanical obstruction.

1. The obstruction following immediately after operation is in most cases due to excessive handling of viscera, or at times caused merely by prolonged anæsthesia and operation. It is a true form of organic ileus. It may be entirely eliminated by the surgeon if proper care is taken not unnecessarily to expose or handle the intestines and sufficient gentleness is used in handling instruments, gauze packs, etc., in the abdominal cavity.

2. Post-operative obstruction due to sepsis and paralysis of the bowel musculature is the commonest of the three forms in appendicitis. In the presence of a widespread and virulent peritonitis at the time of operation it may be at times unavoidable.

3. Obstruction due to mechanical causes occurs generally in septic cases. It may be due to angulation or constriction by new adhesions or the simple glueing together of the intestines by plastic exudate.

Drainage, particularly gauze, with its tendency to excite adhesions, predisposes to obstruction and should therefore be employed as sparingly as possible.

The first variety of obstruction rarely shows itself as more than a transient paralysis of the bowels manifesting itself by cessation of peristalsis and by abdominal distention. Commonly, as the patient reacts, the dynamic force of the bowel is regained and the symptoms of ileus are at an end without ever having excited annoyance or alarm. Occasionally the distention thus engendered becomes marked and distressing.

We may then try various measures which are believed to exercise a stimulating effect upon peristalsis. Cold over the abdomen or hot stupes, if the wound permits of it, may be tried. The introduction of the rectal tube or an enema either of ordinary soap suds or containing a stimulating substance such as turpentine or asafoetida will sometimes initiate effective peristalsis. If nausea or regurgitation be present the stomach tube should be used and the same is true if the distention is upper abdominal or if by percussion the stomach appears distended. An overdistended viscus has small chance to recover from paralysis until the distention is reduced. The only drug of service is eserine, which may be given hypodermically in doses of gr. 1-40, repeated every hour until six or eight doses are given. With every third dose it is my practice to com-

bine gr. 1/60 of strychnia to counteract the depression sometimes caused by eserine. With hormone treatment of deficient peristalsis I have had no experience, and as at present recommended, but little can be said of it.

The second variety of obstruction, which is due to sepsis and toxic paralysis of the bowel musculature, can be combated only by the general measures applicable to intraperitoneal infections as before outlined. The methods given above may aid also in a degree. Only in the event that a definite purulent collection has formed will re-operation be necessary, or advisable.

While it is true that the first two varieties of obstruction do not require operation, great care must be taken to avoid regarding a case of true mechanical ileus as belonging to one of the two former classes, since in no other condition is timely operation so imperative. The cure of angulations, twists or constrictions when they have produced obstruction can be accomplished only by operation, and time employed in lesser measures only lessens the chances of recovery. There may be some difficulty in recognizing the condition. The diagnosis must be made usually by the occurrence of characteristic intermittent colicky pain, accompanied by hyper-peristalsis and borborygmi with increasing distention and inability to pass flatus and to move the bowels. Nausea and vomiting may occur, but are frequently not prominent until later. If the vomitus becomes faecal the prognosis is bad. Similarly peristalsis, which is at first violent and strong, later diminishes and finally ceases when distention becomes marked.

The pulse and temperature are at first but little disturbed, but both rise in the advanced stages. Leucocytosis is an early and pronounced feature. Every effort should be made to arrive at a correct conclusion before the later symptoms appear since prompt operation immeasurably improves the chances of recovery.

One of the most important sequels of appendicitis, whether associated with suppuration or not, is **faecal fistula**. This is of comparative frequency after operations, and there is no question that the likelihood of its occurrence is much increased by delay in the performance of the operation.

Appendicular fistulas occur as one of two varieties—the internal and the external. In the *internal* variety the channel of communi-

cation, or the fistula, is in direct communication with some hollow abdominal viscus, and is entirely within the abdominal cavity. Any of the viscera in close proximity to the appendix may be involved—the intestinal tract, the bladder, a dilated portion of the dilated ureter, etc. In the *external* variety the fistula is in communication with the exterior through the abdominal wall. There may be only a single sinus, or there may be a number of fistulous tracts with a common or two or more external openings. The extent of the lesions and the organ or organs implicated cannot as a rule be determined until the viscera have been exposed by operation.

Of the **external fistulas** there are two varieties—the simple and the fæcal. *Simple fistula* may also be divided into: (1) Those that are the result of an unhealed abscess cavity, and follow the use of drainage. They are merely suppurating tracts that discharge pus, and have a tendency to heal spontaneously. Frequently an infected suture or ligature at the bottom of such a tract, or a fæcal calculus (rarely a piece of gauze) is the cause of the delayed healing. They are more properly sinuses. (2) Those in which the fistula is in communication with the lumen of an appendix and from which there has never been discharged anything but mucus. This type of fistula is encountered in cases in which the lumen of the appendix has become entirely occluded or obliterated at some point, or in which there has occurred spontaneous separation of the appendix in its continuity. This form of fistula is quite rare and is only observed when some portion of the mucous membrane of the appendix is left *in situ*. In one case which I observed there was a small external opening, not large enough to permit the passage of a small probe, which intermittently discharged mucus only. At the time of the original operation it had been noted that the appendix had been separated from the cæcum. Shortly after the operation there developed this fistula, which was treated expectantly, in the hope that it would heal spontaneously. This, however, did not occur. At the secondary operation the remnant of the appendix was found directly attached to the abdominal wall and draining itself through the fistula. A prompt recovery followed its removal. A somewhat similar case, recorded by Jopson, is referred to at page 101.

Fæcal fistula following appendicitis occurs in the two following varieties: (1) Those cases in which the fistula discharges through

the lumen of a perforated appendix and from which as a rule at first faecal matter, and later chiefly mucus is discharged. (2) Those in which the fistula is either caused by pressure necrosis upon, or necrotic inflammation of the caecum, the ascending colon, the small intestine, or both the small and large intestines. In this variety the fistula may be so extensive as practically to constitute an artificial anus.

The exciting causes of faecal fistulas are those which are active in the production of appendicitis, the destructive activity of pathogenic micro-organisms. As a result of inflammation in and about the appendix, necrosis and softening of adjacent or contiguous bowel may occur and the wall of such bowel breaks down, particularly if pus be present. While there are some cases in which pressure necrosis produced by inflammatory lymph results in the formation of a faecal fistula, although pus either is not found or is present in such small quantity as to be scarcely discernible, yet abscess formation is undoubtedly the precipitating cause of faecal fistula in the great majority of cases. In many cases there will be found a large perforation into the bowel, or it will be found that the appendix has separated in its continuity, and that the contents of the bowel are escaping from its proximal end. If at operation it be found necessary to insert stitches into an inflamed bowel, especial care must be exercised not to introduce them too closely nor to tie them too tight, as inattention to either of these points may result in the formation of a faecal fistula.

In many cases of faecal fistula persistence in the use of a drainage tube is one of the most active factors in preventing spontaneous healing. I have seen a number of cases in which removal of a drainage tube that had been worn for weeks was speedily followed by spontaneous healing of the fistulous tract. In particular I recall the case of a young man, whom I saw in consultation and who had recently been operated on twice for appendicitis, and then presented two fistulas. One on the right side discharged bile and faeces, and another, on the left side, discharged pus. In the fistulous tract on the right side there was, and had been for some weeks, a large-sized rubber drainage tube, which extended to the bottom of the pelvis. Removal of the drainage tube was followed by spontaneous healing of the fistula within a short time.

It is not at all unusual for an appendicular fistula to make its appearance a week or ten days after an operation for acute appendicitis, and one should not dismiss from the mind the possibility of such a sequel occurring until the abscess cavity has been in great part obliterated, or even until the wound has healed.

The following is an interesting case in which I operated for the cure of fistula, the result of an attack of appendicitis which was not recognized until an abscess had formed:

The patient was a young woman. The operation was not a complete one, in that the appendix was not removed at the time of the evacuation of the abscess. On account of the softened condition of the intestine forming the wall of the abscess cavity, and because the appendix was not readily accessible, it was deemed advisable not to attempt its removal, but to leave it for excision at a subsequent operation. The abscess cavity was treated by packing. Ten days after the operation the dressings were found to be soiled, chiefly with bile. The fistula not only refused to heal spontaneously, but in addition there developed a most painful eczema of the skin surrounding the external orifice of the fistula. All the well-known topical applications proved of no avail. Operation became imperative, but the patient's condition was exceedingly bad. Because of the painfully irritated condition of the skin, all nourishment by the mouth had to be suspended, and nutritious enemata alone were given. The latter provoked irritation of the rectum. The operation was attended by considerable difficulty. There were widespread adhesions that bound the cæcum to the small intestines and to the region of the gall-bladder, and these necessitated extensive dissection. The fistula was found to involve the jejunum high up, and called for resection. The former abscess cavity was still present; its interior was lined with a grayish, unhealthy looking, granulating surface, which was stimulated, and the cavity was again packed with iodoform gauze. The abdominal wound was closed, except for a short distance, an opening being left to permit of subsequent removal of the gauze. Two weeks after the operation the patient complained of pain. On removal of the dressings it was found that the fistula had recurred; in fact, that it was worse than it had been before the operation. The matter discharged from the fistula was fluid; and if milk, for instance, were swallowed, it was discharged from the wound a few moments after it was received into the stomach. Bile also escaped through the fistula. Owing to the nature of the fistula and the return of the eczema, another operation was determined upon. The opening in the small intestine was found some distance removed from the previous lesion, and the line of suture of the former operation was still intact. There was found in the jejunum a large opening, through which the contents of the bowel escaped. The entire duodenum was ballooned and very much attenuated. The jejunum was excised to the extent of five inches. The bowel was closed by end-to-end anastomosis, and

the thinned portion was reinforced by peritoneal flaps. The abscess cavity was again packed with gauze, and the abdominal wound was closed except at the lower angle, which was left open to afford drainage. This operation was a success. The former abscess cavity soon granulated to the surface, and cicatrization was complete in a short time.

In the external variety of appendiceal fistula the character of the discharge varies greatly. Although profuse at first, the fæcal character of the discharge usually ceases in a short time, and the discharge becomes mucous or muco-purulent, and may continue indefinitely of such character.

It has been my experience that if the appendix be not removed at the time of the evacuation of the abscess, in the majority of cases it will be found to be the source of the fistula.

In a case already referred to (p. 242), the patient was supposed to be suffering from a perinephric abscess, which was evacuated and drained. Three or four weeks after the wound had healed the patient began to complain of pain in the region of the loin, and also of pain in the region of the appendix. He was then admitted to the German Hospital. While being placed upon the operating table, under the influence of the anæsthetic, there was detected a distinctly fæcal odor, as though the patient had had an evacuation of his bowels. On examining the site of the former operation there was found a free discharge of fæcal matter through an opening in the cicatrix. This region was carefully protected, and the patient placed in the dorsal position and an incision made over the region of the appendix, which, when exposed, was found to be post-cæcal and post-colic and to be in communication with the fæcal fistula in the loin. The appendix was much dilated, and permitted of the passage through it to the fistula of the contents of the cæcum. The appendix was removed, the abdominal wound closed, and drainage introduced into the former fistulous tract. Complete recovery ensued.

The **internal variety of fistula**, the result of the evacuation of an appendicular abscess into a hollow viscus, is believed by some to be a fortunate termination of such a case. It has been my lot to see many cases in which the result has been most disastrous. In one case there was a fistulous communication with the bladder, which eventually cost the patient his life; in another

case the fistulous tract emptied into the dilated portion of the ureter, and faecal matter was discharged into the ureter, and escaped externally through the urethra; in another the fistulous tract communicated with the air passages; and so on. The least unfortunate variety of internal fistula is that in which the communication is with the cæcum or ascending colon. I have operated for recurrent appendicitis in which, during the previous attack, the abscess had evacuated itself spontaneously through the colon, resulting in the formation of this variety of fistula.

When the fistula is in communication with another portion of the intestinal tract, it has in many instances been the direct cause of an intestinal obstruction. The fistulous communication between the cæcum and an adjacent loop of small bowel has acted as a band, beneath which another loop of intestine has become engaged, and later strangulated.

The **constitutional manifestations of faecal fistula** are evidenced by gradual loss of strength. If the fistula involves the upper portion of the small intestine, there occurs rapid loss of strength and weight, on account of the loss through the fistula of the contents of the bowel containing the necessary elements of nutrition. In such cases the patient may be constantly hungry. As a rule, the skin surrounding the fistulous opening is most irritated when the fistula is high in the intestinal tract, thus allowing the discharge of unaltered bile and pancreatic secretion through the wound; whereas if the fistula is in the lower ileum, cæcum or colon, the surrounding skin remains in fairly good condition.

The **treatment of appendicular fistulas of the external variety** varies with the individual case. It is always well to permit nature to attempt a cure and such treatment as is adopted should be directed to maintaining thorough cleanliness, and to regulating the diet. The wound should be dressed as frequently as the amount of discharge requires, usually from four to six times daily. The surrounding skin should be protected from irritation and for this purpose I think nothing is so satisfactory as oxide of zinc ointment applied thickly for a distance of several inches around the margins of the wound. It is the only ointment I know which is not at once dissolved and washed away in the discharge. Occasionally benefit will be derived from painting the

surrounding skin with collodion; but this should not be applied if the skin is already sore, as it is then extremely painful to the patient.

The adoption of solid food in the patient's diet, avoidance of laxatives of any kind by the mouth and the daily evacuation of the bowels by an enema are essentials in the proper management of a fistula, which in many instances will heal spontaneously without further interference. It is not wise to use a syringe frequently to irrigate the fistulous tract, such a course being as a rule rather apt to delay healing; but the tract must be wiped dry with small pledgets of absorbent cotton in the jaws of dressing forceps. If the fistula persists after the lapse of a reasonable time, operation offers the only hope of cure.

The **operative treatment of simple fistula** should consist in exploring the tract to ascertain if an infected suture, ligature or other foreign body be the cause. If this be so, it should be removed, and the tract should be curetted and packed with gauze. This usually suffices to insure a cure; but I have known a simple converted into a fæcal fistula by such a procedure, so that it is well to give a rather cautious prognosis.

When the fistula or sinus communicates with an unhealed abscess cavity, the mouth of the fistula should be enlarged sufficiently to permit of thorough cleansing and packing. When possible without opening the peritoneal cavity, the mouth of the fistula should be enlarged to a degree to equal the transverse diameter of the abscess cavity at its widest part. This should be followed by thorough cleansing and packing.

The **operative treatment of fæcal fistula** necessitates opening the peritoneal cavity, removing the appendix or its remaining portion, as the case may be, and thoroughly breaking up all peritoneal adhesions. When the fistula is in communication with one or more openings in the intestine, closure, preferably by suture, is to be attempted. In addition, transplantation of omental or peritoneal flaps is to be advised in suitable cases. It may be necessary to resect a greater or less portion of the bowel, and to do an end-to-end anastomosis (circular enterorrhaphy) or lateral implantation or anastomosis. After closing the fistula in the best way possible under the circumstances, the sutured area should be

isolated by rubber dam or gauze, and the wound treated as an open one, unless the fæcal fistula was very superficial, and it has been possible to excise all the infected wall of the fistula between the skin and its mucous orifice. Of course, where the wound must be treated by the open method, a hernia is to be expected, and this will require another operation for its cure. Occasionally the opening of a fæcal fistula involving the cæcum is so situated and its margin so infiltrated that in the attempt at closure the securing of sufficient healthy tissue to hold the sutures will transgress upon the ileo-cæcal valve. I have had occasion to perform the operation of ileo-colostomy for the purpose of relieving the tension to which the walls of the cæcum were necessarily subjected in the passage of the gas and fæcal contents from the ileum into the colon. An uninterrupted repair was thus made more likely and the patient relieved of danger in the event that the ileo-cæcal junction should be so embarrassed as to cause obstruction to the passage of the contents of the small bowel into the large bowel.

The **abdominal wall may be infected** by the removal of a gangrenous or suppurative appendix. Care should be taken, therefore, to let as little infective material as possible come into contact with the abdominal wound either during the operation or while the wound is healing. This complication may be prevented as a rule by the judicious disposition of gauze or rubber dam.

Usually the existence of fever, leucocytosis, pain or the signs of inflammation in the wound will announce the presence of wound infection and every effort should be made to detect this complication at once since by early opening and drainage the important fascial structures may be prevented from softening and sloughing with subsequent hernia formation. Deep abscesses, that is those which form beneath the fascia or even beneath the muscle in the peritonæal tissues may be very insidious in their development and cause considerable tissue destruction and even sepsis before they are detected. A precaution which I do not know to have been pointed out but has at times been of help to me is to examine the wound in every case of broncho-pneumonia developing after a clean operation. This form of lung infection is in almost every instance embolic in origin and occasionally the source of the hæmatogenous infection is found in the wound. The toxæmia from deep infection

of the abdominal wall may be very severe and at times give rise to distention with lessened or absent peristalsis in a degree simulating obstruction; the temperature, however, is usually high and the presence of pus in the wound can usually be determined by close inspection or exploring carefully with grooved director.

When infection occurs the wound is to be opened freely as far as the infection has extended. Time is lost and nothing gained by attempting to drain an undermined wound through a small incision. The incision must heal from below by granulation.

Stitch abscesses are occasionally a source of much discomfort to the patient, and may materially hinder healing of the wound. They must be laid freely open, swabbed out with corrosive sublimate, tincture of iodine, silver nitrate, or other antiseptic, and allowed to heal by granulation.

Hernia following operation for appendicitis is by no means uncommon. That hernia is most likely to develop when drainage has been employed is readily understood, and the frequency of hernia after operation in cases of purulent appendicitis constitutes one of the strongest arguments in favor of early operation in acute cases. That the occurrence of hernia in the absence of pus is influenced by the length of the incision will be generally admitted. In the very early operation and in the interval operation I am frequently able to remove the appendix through an incision merely large enough to allow the introduction of the index-finger. I have never seen a hernia after so small an incision, and as a consequence I do not advise such patients to wear an abdominal support. The practice of wearing them after operation is a general one; but personally I have little faith in the efficacy of abdominal supporters and I cannot see that they do any good except from the general pressure they afford. Where the belts have to be rigged up with perineal bands it is my opinion that the discomfort occasioned far outweighs the good they accomplish. So far as preventing a hernia is concerned I regard them as absolutely useless.

Even where the operative wound is large, if the case be a clean one, proper suturing of the abdominal wound should in the vast majority of cases prevent the subsequent development of a hernia. Most important for this purpose is the accurate approximation of the peritoneum and of the aponeurotic layers of the abdominal wall—in

the incision I habitually employ, the anterior sheath of the rectus muscle. The peritoneum should be accurately sutured so as to bring fairly broad areas of serous tissue into contact, and also leave no intra-peritoneal protrusions which may give rise to adhesions. The aponeurotic layer should be overlapped by buried sutures, a continuous stitch being more satisfactory in clean cases, since it holds the aponeurosis in more uniform and accurate apposition. Special attention should be paid to the external portion of the rectal sheath, on the side of the wound toward the patient's right, as this is apt to retract to a considerable distance—much further than the median half of the sheath. Splint sutures of silkworm gut including all thicknesses of the abdominal wall down to the peritoneum, should have been introduced before the fascial stitch, but are not to be tied until after this is in place. Superficial sutures, to approximate neatly the skin between the splint sutures, will complete the closure of the abdominal wound.

A wound of even large size, if painstakingly sutured in the above manner, will be very unlikely to give rise to hernia at a later date. In some cases, however, hernia does occur; it may then often be justly attributed to the condition of the abdominal wall itself, either excessively fat, or weak and flabby.

In the event of the development of hernia from any cause, be the hernia ever so small, I strongly advise radical operation for its relief. The pernicious influence upon digestion exerted by hernias, especially small hernias, is well known; and the smaller the hernia, the greater the danger of strangulation passing unnoticed, should it occur.

The **operation for the repair of a ventral hernia** occurring after an abdominal operation should consist in the excision of the cicatrix and the careful denudation of the different layers of the abdominal wall forming the sides of the wound. The peritoneum should always be opened, any existing adhesions, either between the underlying viscera and the parietal peritoneum, or among the viscera themselves, should be disposed of, and the hernial sac cut off flush with its neck. The peritoneum and the different layers of the abdominal wall should then be sutured in the manner just described for the closure of a clean laparotomy wound. The buried sutures are preferably of kangaroo tendon or chromicized catgut; and the

splint sutures are best made with silkworm gut. Superficial sutures of lighter silkworm gut or of horse hair may be employed. I do not use a subcuticular stitch, as it is apt to leave a dead space in the subcutaneous tissues, where fluids may accumulate and delay healing of the wound. The great advantage of the splint sutures is that they prevent any dead spaces by embracing the whole thickness of the abdominal wall, except the peritoneum; and that when they are tightened they relieve, to a great extent, the aponeurotic sutures of all strain. In very fat abdominal walls it is occasionally well to apply a buried continuous suture of catgut in the subcutaneous cellular tissues, thus ensuring still more accurate approximation of the lips of the wound. It is now my practice in patients with fat abdominal walls to unite the skin with interrupted catgut or horse-hair sutures, introducing them one inch apart, thus providing for drainage.

ABDOMINAL PAIN PERSISTING AFTER OPERATION.

Pain which persists even after the removal of a diseased appendix is a sequel seen sufficiently often to render a short discussion of its prevention and treatment of some interest.

If the operation has been performed before the formation of many adhesions, that is, while the disease is still confined to the appendix, it is very unusual for any subsequent discomfort to be experienced.

At times the recurrence of pain brings the unwelcome discovery that we have been mistaken in our diagnosis and that the appendix though diseased was not the source of the patient's discomfort. It has fallen to my lot to remove the appendix in cases that subsequent events showed to have been suffering from movable kidney or renal or ureteral calculus. Fortunately this is a rare occurrence and is mentioned only to encourage thoroughness in the diagnosis of this usually simple condition. Very recently two new conditions have been added to our list of anomalies in the region of the appendix which may give rise to symptoms and if unrecognized cause distress after operation. These are the so-called Lane's kink and the cæcum mobile. Lane's kink in its typical form is a band of peritoneum running from the posterior parietes to the inferior surface of the

ileum near the ileo-cæcal valve. It is not an uncommon finding and I believe but rarely gives symptoms. When, however, it is so well developed and so situated that it can twist, angulate or interfere with the peristalsis of the bowel it may cause pain and particularly constipation, perhaps alternating with diarrhœa. When it is possible to do so the terminal portion of the ileum should be inspected for the presence of this anomalous band.

Cæcum mobile or typhlatonia appears to be, according to Sailer, a congenital malformation of the meso-colon of the cæcum, of such a nature that for some distance along the ascending colon it maintains the type of the mesentery and is not attached to the parietal peritoneum. This permits abnormal mobility, the formation of kinks and partial or very rarely complete obstruction. The wall may become distended, its mobility impaired with resulting constipation and discomfort. Just how frequent is this condition cannot now be asserted though Wilms and certain German authors believe it to be excessively common. As a condition productive of symptoms I believe it to be very rare, an opinion which is based upon a most satisfactory experience in the relief of symptoms located in the right iliac fossa by the removal of the chronically diseased appendix. Still, the condition should be borne in mind and when in the course of removal of the appendix it is seen that the cæcum is abnormally mobile it should be anchored to the posterior abdominal wall by a few retaining sutures.

When adhesions have already formed about the appendix, it is the rule for some adhesions to re-form, and for a few to persist throughout the patient's subsequent life. In patients who have had very many or dense adhesions at the time of operation, intestinal obstruction, as already mentioned, will occasionally occur. More often there is merely aggravated constipation, or rather obstipation, with flatulency, consequent either upon some non-strangulating adhesions, or, as Macewen has suggested, upon the interference with digestion occasioned from removal of the appendicular secretion, and from impairment of the efficiency of that of the cæcum. In any case which has been drained it is almost certain that the omentum or perhaps some of the intestinal coils have become adherent to the under surface of the abdominal cicatrix; and in a large majority of such cases an omental hernia or even an enterocele will

form in the wound. The dangers of this last condition, and the possibility of the strangulation of a small hernia being overlooked, have already been alluded to. Where adhesions to the abdominal cicatrix exist, the patient may complain of tendency to pressure, of a more or less constant drawing sensation, preventing over-extension of the spine, and occasioning severe pain on any sudden movement. Some patients have unexpectedly found themselves relieved of all symptoms after some unusually vigorous motion, being conscious that their adhesions have become separated from the abdominal wall with a momentary stab of pain of unusual severity.

A great many of these patients return to the surgeon seeking relief from their pain by further operative interference. I have operated a number of times for such conditions, and while adhesions have existed in the majority of instances, yet in some patients no cause for the abdominal discomfort could be detected. I think it therefore not impossible that a neurotic tendency may be held accountable for this post-operative pain in certain cases; it is at any rate worth the while of both patient and physician to first consider such remedial measures, other than operation, as are available. I have frequently prescribed a course of mild gymnastics, especially such exercises as tend to bring into play the abdominal muscles, together with Swedish movements, resistive motions, exercise on the parallel bars and on the horizontal bar. Such exercises tend to release the adhesions, if any exist, by stretching and even at times rupturing their attachments, but accomplish this so gradually and so gently that no harm would be anticipated, and none has occurred in the cases under my care. If no adhesions are present such a course of treatment is equally proper for the neurasthenia. Abdominal massage may also be beneficial. If operation is undertaken, the chances of new adhesions forming in even greater strength and numbers are not very remote.

If a hernia is suspected, however, I urge operation, believing that by its radical cure the discomfort of the patient will probably be less, as his danger of developing intestinal strangulation certainly will be.

Pain in the cicatrix or in the neighboring abdominal wall may be attributed to the division of the cutaneous nerves at the time of operation. This is a sequel which it is often more easy to prevent

than to remedy; hence, when possible, long incisions through the rectus muscle should be avoided, since, as was mentioned in a previous chapter, some of the nerves of the abdominal wall are liable to be divided under such circumstances. If a hernia has formed in the wound, its repair, accompanied by dissection and removal of the old scar may result in relief of these symptoms. If any of the main trunks of the abdominal nerves have been divided, the rectus muscle will, as a consequence, be partially deprived of its innervation, and may sag or bulge slightly in the area so affected, favoring the formation of ventral hernia. This fact, as already mentioned, militates somewhat against the universal use of the longitudinal incision passing through the outer border of the right rectus muscle; but unless more than one trunk is divided, the disability produced is negligible, and in incisions of ordinary length no main nerve is divided. Indeed, I am inclined to the opinion that this objection is more theoretical than practical, since I do not remember to have seen a patient in whom post-operative functional defects in the abdominal wall could not with greater justness be attributed to some other condition than to loss of innervation.

In separating or dividing adhesions and dissecting the intestines free from each other, from the omentum, the pelvic organs, or the parietal peritoneum, which it is not always advisable to do, all damage should be repaired as soon as it is inflicted. Areas denuded of their serous covering should be inverted by Lembert sutures of fine silk, or be covered by a graft of omentum, stitched in place; hæmorrhage should be checked by ligature, by suture, or even by packing, this last method being only applicable to bleeding from a bed of adhesions where pressure is possible. Irrigations with hot solutions will also aid in checking the hæmorrhage.

In closing the abdominal wound one of several methods may be employed: (1) Interrupted sutures including all the layers of the abdominal wall; (2) buried sutures uniting the different layers of the abdominal wall individually; and (3) a combination of both methods, or a modification of either. The method of election depends upon whether or not drainage is employed, on the length and character of the incision, and on the development of the abdominal walls.

In clean cases where the wound can be entirely closed it should

always be united in layers in order that the divided structures may be accurately apposed.

In clean cases, with a small wound, I sometimes use a single suture of chromicized catgut for both the peritoneum and the sheath of the rectus, stitching the peritoneum from the lower angle of the wound upward, then transfixing the rectus and its anterior sheath on one side of the wound without tying the suture, and finally stitching the rectal sheath downward to the starting point at the lower angle of the wound, where the two ends of the suture are tied together. I find that this form of suture not only obliterates all dead spaces, but tends to decrease the length of the wound to a very considerable degree.

The peritoneum should first be closed with a running suture of eight- or ten-day catgut. Often, and especially in straight incisions through the rectus I include in this suture a portion of the overlying muscle. Care should be taken with this suture to secure nice apposition of the peritoneum in order to avoid adhesions between the viscera and the resulting scar. Interrupted sutures of silkworm gut are next introduced through all the layers of the abdominal wall down to, but not including, the peritoneum. These enter and emerge at a distance of three-quarters to one inch from the margin of the wound and are placed at a distance of about one inch from each other throughout the length of the wound. These sutures are not to be tied at once but are secured at each end with a hæmostat and allowed to hang loose during the introduction of the remaining sutures.

The aponeurotic layer or layers are next brought together with a running suture of chromicized catgut. It is best to overlap the fascial margins which may be done by transfixing one side and then piercing the other at some distance from its edge. Interrupted mattress sutures may also be used for this purpose and give even better approximation than the running sutures though they are not so quickly introduced. The skin margins are then brought in contact without tension by a few interrupted sutures of fine silkworm gut or horse hair and lastly the through and through splint sutures are taken up and tied over a small roll of gauze tight enough to afford some support to the wound but without undue tension which will result in cutting the tissues. In very fat wounds or in cases

where there has been contamination it is advantageous to pass several very narrow strips of rubber dam down to the muscle between the sutures to provide drainage and lessen the liability of breaking down of the wound.

The dressing of the clean abdominal wound is a simple matter. The wound should be covered by sterile gauze and a cotton pad sufficiently elastic to distribute the pressure and extending far enough from the wound margins to insure protection. The pad should be held firmly in place by adhesive straps which secure a good grip on both sides. These should not be excessively tight, but snug, so as to furnish an additional splint to the wound. The straps should not be drawn tightly across the upper abdomen as they may impede respiration. It is not necessary to treat the skin or impregnate the gauze with antiseptics though it cannot be said that they are harmful if used in a strength that will not cause irritation.

The hermetical sealing of a wound with silver foil or collodion is inadvisable since it may prevent egress of the serous or bloody oozing that occasionally occurs and thus furnish a nidus for infection.

If drainage has been employed a piece of flat gauze may be laid over the closed portion of the wound. A voluminous nest of crumpled gauze should then be applied in contact with the drainage to absorb the discharge. This should be covered by a pad and the whole fixed with adhesive straps as above described. When a glass tube is used this should be isolated from the remainder of the drainage by bringing it out through a perforation in the first layer of gauze and slipping over it a piece of rubber dam about six inches square through a nick in the centre. A small piece of gauze is laid over the opening in the tube and the four corners of the rubber dam folded over it and secured by a safety pin so as to close it off from the remainder of the dressing. A narrow strip of selvedge gauze may with advantage be passed down the tube to the bottom before applying the gauze cap in order to draw up the secretion by capillarity. By arranging the tube in this way it may be inspected separately and aspirated at intervals to determine the time for removal. In order to prevent the drying and coagulation of the exudate upon the gauze covering the wound, it is at times helpful to keep the gauze moistened with Wright's solution (1 part sodium citrate; 4 parts

sodium chloride to 100 parts water). Over the dressing an abdominal binder or many-tailed bandage should be applied to equalize support and prevent the patients from putting their fingers beneath the dressings or otherwise meddling with them as they will occasionally do.

I am careful in all cases, but especially in those where there is much subcutaneous fat present, not to suture the skin surface of the wound too closely, but to leave a half inch or an inch between the sutures. In every wound there is normally a certain amount of serum exuded from the opposed wound surfaces, and if no exit for it is allowed between the sutures it will accumulate beneath the skin, and materially delay the healing of the wound. For the same reason I have almost entirely abandoned the subcuticular suture, which has, in my hands, only too often caused the formation of a subcutaneous collection of serum, necessitating the too early removal of the suture, with consequent gaping of the skin wound, and the production of a more conspicuous scar than follows the use of the customary interrupted or Glover's suture. I may add that I have seen similar unsuccessful results from the subcuticular suture in the hands of other surgeons, so that I do not think they can justly be attributed to faults in technic.

When *drainage is employed*, the buried sutures are used as above described, but they are made interrupted, not continuous, thus avoiding the unpleasant experience of infection of one such suture causing gaping of the whole corresponding layer of the abdominal wound. I always prefer catgut to silk. Splint sutures of silkworm gut are also employed, those inserted where the drains emerge being left long at the ends, and looped, or clamped at their tips by a shot, so as to aid in the repair of the wound by being subsequently tied, when drainage is dispensed with. The buried sutures, of course, extend only as far as the point of emergence of the drains. In some cases it is inadvisable to employ buried sutures of any kind, since rapid completion of the operation is imperative. Under such circumstances the silkworm sutures must include all the layers of the abdominal wall, even the peritoneum; but if after all these through-and-through sutures have been introduced any prolongation of the operation seems justifiable, it will be well to apply a few buried interrupted sutures of chromicized catgut to

the aponeurotic layer, as without such sutures the approximation of this layer, on the accuracy of which depends to a very great extent the subsequent freedom from hernia, is at most very imperfect.

In cases in which there is much putrid and sloughing matter in the abdominal cavity, which cannot be removed at the time of the operation, gauze as well as tube drainage will have to be employed and the wound must be left widely open. Yet it is well to introduce a few interrupted sutures of silkworm gut, even if they are passed only through the skin margins, as without some such barrier above the gauze the bowels will prolapse into the wound. Such sutures must be drawn tight enough only to act as a barrier, and not so tight as to bring the lips of the wound into contact.

In the introduction of the buried sutures I use a round needle for the peritoneum, straight if the wound is large and the walls relaxed, so that it can be conveniently held in the fingers; but a curved round needle in other cases, using as a needle holder a pair of hæmostatic forceps. For the fascial stitch the ordinary triangular pointed, curved surgical needle is used, it being very difficult to force a round needle through such dense tissues. In introducing the silkworm-gut sutures I prefer the ordinary straight surgical needle.

An accident sometimes met with in closing the simple abdominal incision is a puncture with the needle of one of the deep epigastric veins. I am aware of a case in which such an occurrence led to the death of the patient from hæmorrhage. If this accident occurs, the surgeon is not justified in closing the wound until the vein has been ligated. The deep epigastric veins can be exposed by retracting the separated fibres of the rectus muscle then exposing the transversalis fascia between which and the muscle the vessels course. Remembering this fact it is a simple matter to find and ligate the injured vessel. Some surgeons prefer to use a straight round needle for piercing the abdominal wall, thinking it less likely to cut the vessels just mentioned.

THE AFTER-TREATMENT.

The *after-treatment* of a patient operated upon for appendicitis is of the utmost importance, and his welfare depends upon close attention to details. The **general after-treatment**, applicable to all cases, is the following: During the period immediately following the operation while still under the influence of the anæsthetic the patient should be isolated and under the care of a competent attendant, by which is meant a physician or nurse who has had special experience in the management of post-operative cases. Neglect of this precaution will occasionally mean a death from preventable complications. Immediately after operation the patient should be transferred to a warm bed and if necessary surrounded by several hot-water bags to maintain the body warmth, care being taken to avoid burning the skin. During this time the patient should be in the supine position. His pulse, color, temperature and movements should be carefully watched and any deviation from that which is recognized as usual and negligible by the experienced observer should receive attention at once and, if necessary, reported to the surgeon in charge who should always be within call. When the patient becomes rational and quiet, attention may be somewhat relaxed but at no time until it is apparent that danger is past should frequent close observation be neglected. During the first twenty-four or forty-eight hours the pulse, respiration and temperature should be taken every three or four hours and recorded. Any other observations of moment should also be noted. If the wound is not tightly closed the dressings should be inspected occasionally for the first few hours to determine whether there is bleeding.

The **position** of the patient during recovery from the anæsthetic, if general anæsthesia has been employed, should be the dorsal position as already stated. After recovery in simple clean cases the patient may assume either the dorsal or right lateral position, whichever is the more comfortable. There is no objection to changing the position occasionally providing it be done carefully by the nurse, the patient being rolled passively over without attempting to turn himself. The judicious use of pillows often equalizes support and gives greater comfort. An experienced careful nurse will make

use of hot and cold-water bags, gentle massage of aching muscles, and pillow supports in such a way that the patient is made comfortable to a greater degree than by an anodyne.

After recovery from anæsthesia all patients in whom a general diffuse or pelvic peritonitis is present at the time of operation should be placed in the sitting posture. The same position should be used when an abscess has been opened transperitoneally or the peritoneum otherwise soiled. The back must be maintained in an almost straight position. The knees should be flexed, supported by a pillow and the buttocks supported so that the maintenance of this position does not require any effort upon the part of the patient. Considerable skill is necessary to keep the patient in the correct sitting position. Unless this is properly done the patient will slide down in the bed and the back become bent in the lower dorsal and upper lumbar region so that while he has the appearance of sitting, examination will show that the lower portion of the abdomen is parallel with the plane of the bed. In this position the renal fossæ will not drain over the brim of the pelvis and the purpose of the position is partially defeated. Devices for securing the correct position are numerous. The specially made beds and steamer chairs are efficient and valuable in hospital work but are not essential. A sling beneath the buttocks made by a sheet with the ends tied to the head of the bed and a pillow between this and the tubera ischii will secure this position. A triangular trough placed apex upward beneath the mattress will help to keep the patient from slipping and his back may be supported by the special elevator on hospital beds or by pillows placed over the back of an inverted chair in an ordinary bed, or preferably by pillows themselves. The sitting position should be continued until the diffuse peritoneal inflammation and exudation, as evidenced by restoration of peristalsis, subsidence of distention, and the free passage of flatus or fæcal material, has entirely disappeared. When it is not possible to have the patient sitting the head of the bed should be considerably raised.

The purpose of this position is to help the gravitation of septic and infected peritoneal fluids toward the pelvis, this being the least absorbent and dangerous zone of the peritoneal surface and the point most available for drainage.

The after-effects of ether generally encountered are nausea and vomiting and bronchial irritation.

When the patient leaves the table with much bronchial mucus the use of oxygen and of small doses of atropine sulphate gr. 1-100 once or twice repeated as a rule does away with the irritating lung condition. Excessive nausea and vomiting are not only annoying, but in *severe cases* dangerous since they cause diffusion of septic material throughout the abdomen. As long as either persists the giving of fluid by the mouth is absolutely contraindicated. There is but one rational treatment for vomiting and it is always successful unless the vomiting be caused by severe toxæmia, by general and progressing peritonitis or by the presence of obstruction. This is gastric lavage, thoroughly carried out and repeated until its end has been accomplished.

Lavage when carried out upon patients having an abdominal incision should always be accompanied by precautions regarding the wound. The additional straining during the washing out of the stomach may cause damage to the incision and therefore it is important that some additional support be given it by firm counter-pressure by the hands of an assistant.

Plain fairly warm water or salt solution should be used, though there is no objection to the addition of carbonate of soda to aid in the removal of mucus from the stomach. I believe there is always a certain danger to the gastric mucosa in the use of the bulb of the stomach tube and prefer to employ simply the siphon principle. In order to be of the greatest value lavage must be continued until the fluid returns from the stomach clear and clean with no coloring matter or mucus. It must be repeated at intervals until it has fulfilled its purpose. It is the only treatment for vomiting and the only preventive for that very grave but fortunately rare complication, acute gastric dilatation.

The use of drugs or external applications to allay post-operative vomiting is usually futile and is to be avoided.

Stimulation if necessary may be given the patient in one of several ways. The use of saline—afterward to be mentioned more at length—is to be commended in case of emergency. When the patient is in any way shocked or depressed after operation the use of a saline enema of 1000 c.c. with the addition of 30 c.c. of whiskey

or strong coffee is indicated together with diffusible stimulants, such as camphorated oil in the usual doses. When in an emergency more rapid stimulation is needed hypodermoclysis or intravenous saline infusion must be used. The addition of a small amount of adrenalin or pituitrin to the salt solution when given intravenously aids in raising the blood pressure. The effect of pituitrin is somewhat more lasting than that of adrenalin. I advise that these drugs if employed should be given hypodermically as their intravenous use has been reputed in several instances to have caused death.

Normal salt solution in conditions of great urgency may be given with advantage into a vein or beneath the skin. The amount of fluid to be introduced is to be regulated by the gravity of the condition and the effect that its administration produces. On the average 500-1000 c.c. ($1/2$ to 1 qt.) under the skin and 1000-1500 c.c. (1 to $1\frac{1}{2}$ qt.) into a vein should be used for this purpose.

Of the drugs so commonly employed in this condition, strychnia is of no value in shock and digitalis is too slow in its action to be of immediate service. The drug, namely morphia, which is most valuable in the treatment of shock proper is the one which unfortunately should not be employed in the after-treatment of appendicitis if avoidable. When given for this definite indication and not as a routine measure for the comfort of the patient its use is to be commended

In the absence of peritonitis small amounts of water or ice may be given within ten or twelve hours providing nausea has not been present for at least six hours. Nothing should be introduced into the stomach if the patient has recently vomited or is in the least nauseated. Thirst is much diminished by giving saline by rectum, which is a wise practice even when no peritonitis exists. Nourishment should be withheld until the stomach is retentive of fluid and flatus is passed freely. I am not at all in sympathy with the practice of giving water immediately after operation before peristalsis has been established.

The first feedings should consist of a dram or two of albumin water, buttermilk, tea or broths, which may be given in gradually increasing quantities at intervals of two or three hours, and the quantity may be so increased that at the end of the third day six or eight ounces are taken every three hours. Milk is usually an un-

satisfactory food for early administration on account of its tendency to cause flatulence and distention. The patient is kept on strictly liquid diet until the bowels have been moved spontaneously or by enema on the third or fourth day. After that the diet is increased gradually so that at the end of the first week full diet is taken.

In cases with localized abscess the same routine is followed except that the period of liquid feeding or feeding on very soft foods which produce little faecal residue is prolonged until practically all drainage material has been removed from the wound. This is done to minimize the chance of intestinal obstruction, which is rendered more likely by the presence of considerable material within the bowel.

In peritonitis, diffuse or general, nothing whatever is given by mouth until peritonitis has subsided and peristalsis is established, be this twenty-four, forty-eight, seventy-two hours or even longer. Then water is given sparingly and liquid diet begun gradually and continued until all danger is past. It would be impossible to deprive patients of water and nourishment for so long a period of time. even while assuaging thirst by rinsing or wiping the mouth with cold water were it not for the use of saline by the bowel.

Saline enteroclysis by the continuous method of Murphy which has been described previously is the greatest advance in the post-operative treatment of abdominal conditions in the last decade. I use it as a routine measure in all cases of diffuse peritonitis and by it have been enabled in such cases to reduce the mortality to less than 2%, a percentage unattainable by older methods of after-treatment. The saline thus given dilutes the toxins of the blood, lessens thirst, provides much needed fluid, stimulates the kidneys, increases blood pressure and acts as a general stimulant. Locally it lessens absorption by the peritoneum and at times seems to make of the peritoneum a secreting and not an absorbing area.

The use of continuous saline enteroclysis is indicated in all cases of appendicitis where there is infective exudate or fluid not sharply localized, when shock or depression after operation is marked, when there is marked septic absorption or when the renal function has been impaired. It is an indispensable adjunct in the after-treatment of such cases. Continuous saline enteroclysis

should always be employed unless there be no attendant capable of administering it.

For rectal administration half-strength normal saline solution is used. This is well tolerated by the bowel and the absorption of excessive amounts of salt is thereby avoided.

When it is not feasible to use this method saline enemas of from 250-500 c.c. ($1/2$ -1 pt.) every three or four hours may be given but do not act nearly so well. The use of nutrient substances in the saline enemata is not usually necessary. When, however, the patient must be deprived of food for several days it is helpful to add small quantities of predigested beef and dextrose. Whiskey also is easily absorbed through the lower bowel and in some cases, particularly the toxic, is of value. Rectal alimentation at its best is of little moment and as usually employed in the use of undigested materials and complicated formulas is useless. As Paterson says, rectal alimentation is only another word for starvation.

The urine must be carefully measured after operation and should be examined microscopically and chemically daily for at least a week afterward. The amount is more important than the character. In some patients catheterization may be necessary for a day or two after operation and should be carried out with the strictest precautions as to cleanliness. Immediately after operation the patient may be allowed to go eight hours or longer if the bladder is not distended or the patient uncomfortable, before being catheterized, and if it be necessary afterward it should be done not oftener than every eight hours under ordinary conditions. When continuous saline enteroclysis is used the amount of urine is always greatly increased.

In patients who are very toxic, the aged or debilitated or those who have previously had renal disease there may be marked insufficiency of the kidney function. The quantity of urine is decreased and albumin and casts become plentiful. The prompt and continued use of saline by the bowel or hypodermoclysis at intervals, aided if necessary by sparteine, gr. $1/4$ and caffeine gr. $1/2$ hypodermically is usually an aid in this condition, which depends, however, more upon the degree of toxæmia present than upon any other factor. In almost every case there is for a few days after operation a slight quantity of albumin in the urine and often we

find a few casts and occasionally sugar in small quantities. This should not be a cause for alarm unless there is a concomitant marked decrease in the quantity of urine voided and the condition does not clear up in a few days.

The bowels after an operation for appendicitis require no attention for three or four days. Then an enema should be given. The bowels if sluggish should be moved routinely by enema, though there is no objection to an occasional dose of castor oil or calomel in small doses if the patient has a foul mouth or coated tongue. Where peritonitis is present it is best to use enemas only and these should be given very gently so as to affect only the lower bowel. Enemas forced high in the bowel may cause peristalsis of the small intestine. When the saline enteroclysis is used a cleansing enema will be necessary when the fluid in the reservoir becomes stained showing that peristalsis is beginning to propel faecal material into the lower bowel.

With regard to the **special after-treatment** of cases operated upon, they may, for convenience, be classified as follows: (1) Simple, uncomplicated cases in which the abdominal wound is completely closed at the time of operation; (2) cases of local supuration in which rubber-tube drainage has been employed, the tube being usually surrounded with gauze; (3) cases of diffuse peritonitis.

1. In *simple, uncomplicated cases*, if the temperature and general condition of the patient show no abnormalities, the wound is not dressed for five or six days, when the dressing should be changed, the skin gently cleansed with alcohol and a sterile dressing applied; the sutures may be permitted to remain undisturbed for two or more days longer, if there is no evidence of stitch irritation. When the sutures are of silkworm gut or horse hair they can be removed on the seventh or tenth day; if catgut is employed it is not necessary to remove it, but unless it is absorbed it is well to do so in order to remove a possible source of irritation. A sterile dressing of gauze should still cover the wound until every vestige of scab is removed, and the scar is firmly healed. A rise of temperature or a decided increase in the local pain, necessitates immediate changing of the dressings and a careful search for the source of irritation. Stitch abscesses usually develop early and should be opened and

treated on general principles. If pus should form within the abdomen, the case alters its aspect and becomes one of the following classes.

The patient may be allowed to leave his bed at the end of a week, or even in some cases as early as the fifth or sixth day, where the incision has been a small one. For the first week or ten days after the patient begins to move about, his abdominal wall should be supported by an ordinary circular bandage or broad adhesive straps. I have stated elsewhere that I do not consider abdominal supporters of much value, except perhaps when the incision has been unusually large or left unsutured at the time of operation for the purpose of drainage.

2. Cases with *local suppuration* and drainage by tube, gauze or both, may require stimulation as previously mentioned. In some of these cases it will be found necessary to continue the use of stimulants, tonics, and especially nutritious diet, for a considerable time. In depressed states massage, oil rubs, sun baths and fresh air are often very helpful.

The dressings, in cases of local suppuration, need not be disturbed until the third or fourth day after the operation, unless the outer dressings have become soiled by the discharge from the wound, or unless some unfavorable symptom makes earlier inspection of the wound advisable. In case the outer dressing does become soiled, it should be changed immediately, and in some cases it is necessary to do this twice daily. The dressing in immediate contact with the discharging surface should be moistened with Wright's solution (1 part sodium citrate, 4 parts sodium chloride to 100 parts water) to facilitate exudation. The outer dressings should be kept dry. When the dressings remain saturated with blood or serum or even with purulent exudate, bacteria may rapidly infect by continuity. As a rule at the end of the third or fourth day these outer dressings must be removed and the skin surrounding the wound gently cleansed. Only in exceptional cases should any of the gauze packing be removed this early. The too early removal of gauze packing frequently produces disastrous results by opening avenues by which infection may extend to the surrounding coils of bowel, causing a peritonitis or secondary pus collection. In addition, fully formed granulations are crowded with leucocytes preventing absorption,

and if the bowel surface is injured too early by the removal of gauze such protection is not afforded. If the case is one where an appendiceal abscess was opened extra-peritoneally, little or no gauze will have been used around the tube; in such cases it may be well to remove this gauze at the first dressing, and, having cleansed the tube, to replace it with less gauze, allowing the abscess cavity to close gradually by the pressure of the neighboring coils of bowel. But where a coffer-dam of gauze has been used, the adhesions between the surrounding loops of bowel will not be sufficiently firm at the end of three or four days to ensure the general peritoneal cavity from infection if the protecting gauze is removed; and besides this consideration the too early removal of the gauze is very painful to the patient, and is apt to cause bleeding from the adherent bowels. After five to eight days, however, it will be found that the granulations on the peritoneal surfaces in contact with the gauze have reached such a stage of development that usually the gauze may be removed with little pain and considerably greater facility than at an earlier date. Before attempting the removal of the gauze, each piece in turn should be thoroughly saturated with warm normal saline solution, sterile water, or boracic acid solution; and in their removal neither haste nor force should have any place. Unless their removal proceeds with the utmost gentleness, the protective adhesions may be torn, or the bowel or omentum may be dragged into the wound. Even when the greatest care is exercised this may occur once in a great while. If it does, the bowel or omentum should be replaced and held in position by pieces of sterile gauze until the remaining gauze has been removed. It is sometimes wise not to attempt the removal of all the gauze at the first sitting, but, after thoroughly saturating the most firmly fixed pieces, again to attempt their removal after the lapse of eight or twelve hours. It is not necessary to irrigate the abscess cavity, but the pus should be carefully mopped away. The tube should be replaced if there is anything further to be drained; but as a rule all that is required after the first week or ten days is to keep the wound open and allow it to heal by granulation from the bottom.

In those rare cases where a cigarette drain has been employed, without a tube, and where there was practically nothing to drain, it is usually well to remove this gauze plug on the second or third day.

If no bad odor is present, and the gauze is practically unsoiled the subsequent management of such cases is the same as that of those where the wound was completely closed at the time of operation; but extra attention should be paid the case on account of the possibility of suppuration progressing beneath the wound.

3. In cases where at the time of operation there was *diffuse peritonitis and exudate* drainage will have been employed either by a glass or rubber tube extending to the pelvis, supplemented occasionally by wicks of gauze. It is my practice to place the patients in bed in a semi-sitting posture and give continuous enteroclysis. All nourishment by the mouth must be withheld for the time being, and ice-bags placed over the abdomen for the patient's comfort.

If a glass tube has been employed, its extremity should project beyond the other dressings, and should be covered with sterile rubber tissue containing a gauze sponge to absorb any fluids that may be drained out by the capillary action of the gauze wick placed in the interior of the tube. In addition, the nurse in attendance should be provided with a long-nozzled syringe (a rubber tube attached to the nozzle of an ordinary syringe will answer the purpose) to suck up from the pelvis through the glass drainage tube any purulent material that accumulates. During the first eight to twelve hours the glass drainage tube should be exhausted every few hours, according to the amount of fluid that accumulates. During the intervals a strip of gauze should be re-inserted through the drainage tube into the pelvis, and it will commonly be found that some, at least, of the extravasated matters are absorbed in this manner into the gauze covering the outer extremity of the glass tube. The most painstaking care should be taken not to further contaminate the peritoneal cavity. To this end the suction apparatus should be repeatedly sterilized, and the nurse's hands should be surgically cleansed each time the tube has to be exhausted. During the first twelve or twenty-four hours the amount of fluid which collects in the pelvis will be found to gradually diminish, until on the second day it will usually be necessary to exhaust the drainage tube only every three or four hours, and subsequently at even greater intervals. At each dressing the tube should be given a half turn to loosen any adhesions which the omentum or bowel may have formed to the fenestrations of the tube. When the amount of fluid becomes insig-

nificant and of a straw color—usually on the second or third day—the glass tube may be removed, and, if necessary, a rubber tube of smaller calibre substituted, introducing the rubber tube through the glass tube before the latter is removed. The periodical exhaustion of the tube may then be discontinued. A rubber tube is generally much less irksome to the patient than one of glass and after the peritoneal discharge has nearly ceased, drains equally well. The rubber tube is to be withdrawn gradually cutting off an inch or two at each dressing.

If gauze drainage, either in conjunction with a glass tube or without one, has been employed in these cases, it should not be disturbed for five to ten days, except to loosen it if the discharge is dammed back. In these cases, even more than where the suppuration is localized, are skill and dexterity requisite to dress the wound, and to prevent the prolapse of the bowel or omentum. Great care must be exercised in replacing the gauze, on the one hand not to leave any suppurating pockets undrained, nor on the other to produce intestinal obstruction by packing the abscess cavity too tightly. The management of the pelvic tube is the same in these cases as in those when no gauze has been employed.

APPENDICOSTOMY.

Appendicostomy consists in the establishment of a fistula through the appendix into the cæcum, the chief object being to afford a means for the introduction of fluids into the large bowel (Russ).

The operation has been employed to accomplish the irrigation of the colon in various forms of disease of that portion of the intestine and occasionally to meet certain other indications arising from abdominal disease or operative procedures.

It has found by far its greatest usefulness in the treatment of amœbic dysentery, mucous colitis and ulcerative conditions of the colon. Berry and Whitmore had most excellent results in true chronic dysentery, six of ten patients recovering. As early as 1905 Willy Meyer reported his excellent results in cases of amœbic dysentery and ulcerative colitis. Tuttle states that of forty-four cases of chronic amœbic dysentery treated by appendicostomy, thirty-eight recovered. Russ reported two cases in his own practice with most

encouraging results. Gaut speaks favorably of his own results in dysentery and colitis.

Keetley in an exhaustive review of the subject states that the operation has been used in dysentery, colitis, intestinal hæmorrhage, after enterectomy and colectomy for intestinal distention of toxæmia, in cases of malnutrition or chronic constipation and in pernicious anæmia. He himself reported a case in 1905 in which the operation was performed upon a child after the reduction of an intussusception to anchor the cæcum, for lavage of the intestine and for the possible injection of saline in case of collapse. The same author also employed appendicostomy in cases of typhoid fever.

The technic of appendicostomy is simple. Making an incision through the rectus muscle as for an appendectomy (Keetley, Meyer) or a muscle splitting or McBurney incision (Rodman and Anders) (Russ) the appendix is brought into view. Barry and Whitmore state that the operation may be readily performed under local anæsthesia. The appendix is placed straight through the incision (or obliquely, Keetley, Meyer), and the cæcum stitched to the peritoneum. Certain operators lay stress upon going through the meso-appendix and not around the appendiceal artery, others state that this is an unimportant detail provided that that portion of the appendix beyond the tied off appendiceal artery be brought out of the wound. The appendix having been brought out through the incision, the latter is closed by layer sutures leaving the tip of the appendix exposed. The actual opening into the appendix may be made at once or twenty-four to forty-eight hours afterward as a secondary operation; the latter seems to be the method most favored by those experienced in the technic of the operation. The appendiceal fistula having been made, irrigation of the colon may be performed by means of a small catheter passed into the lumen of the appendix. After appendicostomy has been performed the only serious accident that might occur is the slipping back of the cæcum and the appendix, as in the case reported by Meyer. Usually there is no difficulty in closing the fistula; indeed, the difficulty in cases of appendicostomy is rather to keep the lumen of the appendix open as it shows a great tendency to close spontaneously.

Personally this operation has never appealed to me strongly. With the exception of amœbic dysentery and perhaps a few cases of colitis its field of usefulness I think is very small.

COMPLICATIONS AND SEQUELS.

The complications and sequels of appendicitis are many and varied. Some of them—as circumscribed peritonitis, for example—are in many respects rather a part of the disease than one of its complications; others, as diffuse peritonitis, gangrene of the bowel, abscess of the liver, etc., are of much more serious moment, and greatly interfere with the prompt recovery of the patient, or cause a fatal issue; others, which may or may not pertain to either of the foregoing classes are of importance only as they render more or less difficult the proper surgical treatment of the affection.

It is thus convenient to divide a consideration of the complications and sequels into: (1) The complications due to the disease itself. (2) The sequels of the operation.

Such a division must occasionally be somewhat arbitrary, as, for example, the occurrence of intestinal obstruction which, following operation, is nearly always due to the peritonitis produced by the escape of infection from the appendix; or fæcal fistula, which may occasionally occur where no operation has been performed and which is almost always caused by local necrosis of a cæcum infected by a diseased appendix. The post-operative complications in the last 2400 cases of acute appendicitis have been carefully compiled. Of these, 1997 cases occurred in the German Hospital and were in adults, and 403 cases were in children under treatment at the Mary J. Drexel Home. These cases are tabulated at the end of the chapter.

COMPLICATIONS OF APPENDICITIS.

Of the complications that pertain to the disease itself **peritonitis** is the most frequent, and the most important. In every case of acute appendicitis the peritoneum reacts to the irritant and secretes a serous effusion, the quantity of which depends upon the amount and virulence of the bacteria or their toxins, or both. Nature then offers two measures by which the process may be rendered

harmless and the patient recover. The first and most common is by the formation of protecting and encircling adhesions which tend to confine the infection to a localized area. The other method consists in the peritoneum reacting to the irritant by effusing from its surface an amount of fluid and phagocytes proportionate to the irritation, diluting the toxins and furnishing antibodies and phagocytic cells which endeavor to check bacterial invasion. The anti-toxic action of this effusion explains the rapid recovery of the peritoneum from infection after removal of the appendix, if operation is performed early. The five most frequent locations of *local suppuration* have already been described in the chapter on Treatment, and the procedures proper to be employed in each case have there been discussed in considerable detail; so that it is unnecessary to do more here than urge the importance of evacuating all such abscesses at the earliest possible moment, so as to prevent sepsis and secondary perforation of the intestinal tract. *Diffuse suppurative peritonitis* is a much more fatal complication. It occurs under two chief forms, as already described in the chapter on Pathology. In the first many adhesions are formed, and small abscesses arise here and there between the intestinal coils; in the second, few if any adhesions are present, and the intestines float free in a bath of pus. At times a dry peritonitis is encountered without adhesions. This form is usually due to the streptococcus and is peculiarly virulent.

In certain of the suppurative and gangrenous cases of appendicitis, and particularly when the abscess of the appendix lies behind or to the outer side of the cæcum or colon, the surrounding tissues will be found partially or completely gangrenous. This retro-peritoneal form of sepsis is an infection by continuity, and not by way of the lymphatics; since, as is well known, the lymphatics of the appendix do not empty into the retro-peritoneal tissues in this situation, but pass to lymph glands lying in the angle between the ileum and the colon and along the ascending colon. In cases where the disease presents this type, the wound must be treated as an open one, as has been fully described when discussing the operative technic for appendicitis. The retro-peritoneal lymphatics when infected may result in peri-pancreatic inflammation and abscess of the pancreas, as I have seen.

Bowel necrosis is a very serious complication of appendicitis.

The appendix may perforate directly into the cæcum or another portion of the intestinal tract to which it has become adherent; or an abscess, formed around the appendix, may rupture into some portion of the intestinal canal; or, where diffuse suppurative peritonitis exists, with multiple abscesses among the intestines, any one of these, or several of them, may ulcerate into the neighboring intestine, and a fæcal fistula will thus be formed even before an operation is undertaken. Instances of perforation into the duodenum, ileum, cæcum, colon, sigmoid flexure and rectum have been reported. In 2400 cases necrosis of the bowel was observed in twenty-one instances, of which twelve recovered and nine died.

A diseased appendix or a collection of pus about an appendix may be in relation with, and give rise to **necrosis of the iliac blood-vessels**. The vein is more likely to become involved in the inflammatory process than is the artery, probably for the two reasons that its coats are thinner, and the blood within it circulates less rapidly. Whichever vessel be involved, perforation of the vessel with fatal hæmorrhage may ensue. Secondary hæmorrhage of this type may follow incision and drainage of an abscess, though fortunately this is a rare complication. The hæmorrhage may be controlled by gauze packing or failing this, operation and ligation of the bleeding vessel must be resorted to. Pevvel has recorded a case of perforation of the external iliac artery. It is more common, however, for an **arteritis** or a **phlebitis** to occur. This results in thrombo-arteritis or thrombo-phlebitis, which may give rise to embolic processes. Schelbenzuber has reported an unusual case of embolism of the left anterior tibial artery with consequent gangrene of the leg, and Bérard a case of obliteration of the right crural artery, the result of arteritis. Of the venous involvements may be mentioned inflammation of the right iliac vein, of the right femoral vein, of the left femoral vein, of the mesenteric veins, and of the portal vein. Inflammation of the veins of the extremities is not so rare from other causes as to require illustration in this connection. Mesenteric thrombosis has already been discussed in the chapter on Differential Diagnosis. Eleven of 2400 cases are recorded as having had phlebitis after operation.

Inflammation of the portal vein, however, with a consequent suppurative hepatitis, is not very infrequently seen. These in-

inflammations are infectious, and give rise to infectious embolic processes, which are met with under the forms of **hepatic abscess** and **suppurative pylephlebitis**. Occasionally these conditions co-exist, as in the following case:

A. T., a white male, aged twenty-two years and a bartender by occupation, had a negative family history. His previous personal history was also negative—he had had only the ordinary diseases of childhood. During the eighteen months prior to first observation he had had three or four attacks of colic, attended by vomiting. There was no recollection of localized pain. These attacks usually subsided within a few days and he was able to return to his work.

On March 1, he developed a sore throat, which was accompanied by stiffness of all his extremities and was followed by excruciating griping pains in the epigastrium, which were increased by deep inspiration. He had chills, fever, and sweats at irregular intervals; headache and backache; his appetite was fair and his bowels were loose. When seen by his attending physician on March 15th, he presented the following symptoms: Temperature, 103.4° F.; pulse-rate 96; hectic flush on the cheeks; extreme pain and tenderness and slight tympany in the epigastrium. His tongue was thickly coated; his heart and lungs were normal. His urine contained a trace of albumin and a few granular casts. Blood examination revealed the normal number of erythrocytes and leucocytes, and the normal percentage of hæmoglobin. Microscopically, a few intracellular organisms, resembling the hæmatozoa of malaria, were found. During the succeeding night he had a severe chill and profuse sweating. The following morning at 5 A. M. his temperature was 98° F. and his pulse-rate was 80. A serous diarrhœa then set in. Quinine was administered without relief, and no change in his symptoms was noted until March 19th, when, with a morning temperature of 96.6° F., his pulse-rate was 104. His pulse was irregular, there was general abdominal distention, accompanied by marked tenderness and tympany, and a general peritonitis had evidently supervened. The diarrhœa continued, the pulse was rapid and irregular, and the patient grew weaker, and died April 4th. At necropsy, performed eight hours after death, there was detected a general peritonitis due to a ruptured abscess of the liver. The appendix was perforated and was embedded in a mass of necrotic adhesions. There was purulent inflammation of the portal vein extending into the liver substance. In the upper part of the right lobe of the liver there were numerous embolic abscesses, one of which, situated near the surface, had ruptured beneath the diaphragm.

This case, which came under my observation at necropsy only, is reported: (1) To demonstrate the importance of excluding primary appendicular inflammation in the diagnosis of all intra-abdominal affections, particularly when pain and tenderness are not referred to the right iliac fossa; and (2) to emphasize the value

that should be attached to a history of previous attacks of colic with gastric irritation, as indicating early involvement of the appendix—from which as an infectious focus other organs may subsequently become involved.

Unfortunately fatal suppurative hepatitis may occasionally follow even comparatively early removal of the appendix, if time has elapsed sufficient for perforation of the walls of the appendix by the infecting bacteria.

C. L., colored, age twenty-eight years. Family and personal history good. Present trouble started thirteen days before admission to German Hospital November 30th, 1904, with acute paroxysmal pain over right abdomen, radiating to pit of stomach. Paroxysms every ten to fifteen minutes for eighteen hours, pain then became localized to right iliac fossa and gall-bladder region. Bowels opened by oil and enema. Patient vomited five or six times. Three days later he began to become jaundiced, gradually increasing to a deep yellow color. Stools clay color; tongue coated.

Examination showed rigidity of entire right abdomen, tenderness over appendix and gall-bladder region; slight distention, liver dullness decreased, probably from gas. Had a slight cough and few râles over base of right lung.

Operation.—Incision well toward spine of ilium; peritoneum opened over a small abscess. Pus sponged out and faecal concretion removed. Abscess cavity packed with iodoform gauze. The patient died in a few days.

Pathological Report. Special Observations.—Peritoneal cavity showed no free pus. Appendix was found somewhat anterior and pointing straight toward the pubis. It was gangrenous, about 6 cm. long and showed a large perforation at its middle. There was a small pus pocket, containing a few drops of pus, at this point. The colon at and above the ileo-cæcal valve showed beneath serosa small areas of purulent material up to almost the transverse colon. Upon opening it there was found a purulent and ulcerative colitis, extending up almost ten inches. Small intestine congested. The mesenteric glands were enlarged. Superior mesenteric veins in some places on section showed pus because of a phlebitis. Spleen slightly enlarged and much congested. Liver very much enlarged and a hand's-breadth below the costal margin. Weight 3600 grammes. A curious extension of the left lobe was noted as a very flat portion. The surface and interior of the liver showed multiple abscess formation, the abscesses being not yet well defined or broken down. The veins showed a phlebitis. Gall-bladder normal. Lungs: the lower lobe of the right lung was very pale with many anthracotic spots. Kidneys: right, normal, very pale; left, enlarged and pale.

The subjects of hepatic abscess and pyelophlebitis have been studied by Pellegrini, by D. F. Jones and by A. K. Gerster. From

various authorities quoted by these writers it appears that suppurative pylephlebitis or hepatic abscess occurs in from 1 to 2 per cent. of all cases of acute appendicitis, and that of all intestinal lesions inflammation of the appendix is the most frequent cause. At the present time these figures are certainly too high due to the practice of early operation before the inflammation has seriously attacked the efferent veins. Still it is a complication to be reckoned. If the whole portal vein becomes the seat of septic thrombosis the inflammatory process spreads to its minutest branches in the liver, forming a true suppurative pylephlebitis, as in the case just recorded. If, however, a single embolus lodges in the liver only one abscess is formed at first, though others may arise either by subsequent emboli becoming lodged, or by extension from the original focus of suppuration in the liver. Infection of the liver is probably always produced by way of the portal system, as the retro-peritoneal lymphatics do not drain into the liver; this is well shown by the rarity of liver abscess as a complication of appendicitis where the appendix lies in the retro-cæcal cellular tissue, or even in contact with the liver; also in cases of peri-nephric abscess. Moreover, the superficial lymphatics of the liver itself drain from its centre toward the periphery like the bile and do not pursue a centripetal course as does the blood in the portal vein.

The *symptoms* most to be relied on in the diagnosis of suppurative hepatitis are the following: First and foremost, it is important to learn the history of the case, to detect if possible a preceding appendicitis, or any disease simulating its usual symptoms, since in many cases pylephlebitis follows an attack of appendicitis which has passed entirely unnoticed. Rarely will any symptoms referable to the liver be detected earlier than the fifth or sixth day, and they may be delayed for several weeks. If, however, a patient known to have had appendicitis, presents, after a suitable interval of time, sudden epigastric or right hypochondriac pain, with a chill, and develops tenderness over the liver, with perhaps pain on deep inspiration, and jaundice, hepatic complications should be suspected. Special attention is called by Gerster to the frequency with which this dreaded complication results from operations performed even after the acute attack has subsided, and thorough postmortem examinations are suggested in such cases in order that if possible

undeserved blame should be removed from the operator who has had the misfortune to operate upon a patient with a septic thrombus which is ready to be detached and carried into the portal circulation on the slightest provocation. It may be difficult at times to exclude a right-sided pleurisy or pneumonia; an examination of the blood should be made to exclude malaria; while careful physical examination will usually render evident the absence of malignant endocarditis and miliary tuberculosis. All of these diseases are liable to present somewhat similar symptoms. Tenderness on deep pressure over the liver is the most valuable local sign; occasionally, if the hepatic abscess contains gas, a tympanitic note may be obtained. Puncture or aspiration of the liver for the purpose of detecting suppuration is a dangerous as well as an uncertain method of making a diagnosis. Even puncture of the exposed liver will frequently fail to reveal the presence of pus, although a good-sized abscess be present.

At a later stage the pain and tenderness are often diminished; diarrhoea may set in, jaundice may be detected, and there may be bile in the urine. If numerous chills occur it is extremely probable that the affection is a suppurative pylephlebitis, and not a single abscess of the liver, since each new extension of infection almost invariably produces a rigor. The temperature is extremely irregular, varying from 100° F. to 104° F. In the later stages of the disease the fever is more constant and is remittent in type, while the chills disappear although profound sweats occur. If only one or two abscesses are present in the liver this organ may be noticeably enlarged. If relief is not soon afforded, sepsis progresses, the patient may become delirious, and finally death from exhaustion ensues.

The question of *operative treatment* is even more unsettled than is that of diagnosis. It is impossible to drain multiple diffuse abscesses of the liver. One or two larger-abscesses may, however, be evacuated and recovery ensue.

At times a **peri-appendicular abscess** may burrow upward behind the liver, either through or posterior to the diaphragm, and may finally **rupture into the lung**, the pus being expectorated. The following is an illustrative case:

R. S., a male, aged nineteen years, was admitted to the German Hospital on August 25, 1895, and the following history was elicited: He had always enjoyed good health until three days prior to admission, when, after a hearty

meal, he commenced to complain of pain in the epigastric region. This was attended by vomiting, which afforded no relief. The pain increased in severity and became localized in the right iliac fossa, which was markedly tender on pressure. The vomiting finally ceased, but nausea persisted. The patient considered himself afflicted with an ordinary attack of intestinal colic, and did not summon medical aid until the pain had become unbearable. He was sent immediately to the hospital, where, upon admission, his temperature was found to be 102° F.; his pulse-rate 94; his abdomen slightly distended and rigid, especially upon the right side, where tenderness was most marked. He complained of general abdominal pain.

A diagnosis of appendicular abscess was made.

Ice-bags were applied to the abdomen and saline purgatives were administered. Some abatement of the pain and tenderness resulted. Although operation was strongly advised, it was absolutely refused by the boy's parents. At this time his temperature ranged from 99° to 99.8° F.; his pulse-rate from 84 to 100. He was, however, fairly comfortable, despite occasional nausea and vomiting and the continuance of abdominal tenderness. He remained in this condition until the fourth day after admission (the seventh day of the attack), when he suddenly grew worse, his temperature rising to 104° F. and his pulse-rate to 120 a minute. He vomited continuously, became dyspnoëic, and expectorated large quantities of fœtid, muco-purulent matter, tinged with blood. Examination of this revealed no tubercle bacilli. The patient became exhausted and died nine days after admission to the hospital.

At necropsy a perforated appendix, pointing north, and lying just below the diaphragm, was found. The abscess surrounding the appendix had perforated through the diaphragm into the lung, which revealed some gangrenous areas. The expectorated matter was evidently some of the contents of the peri-appendicular abscess.

In addition to this case I have encountered several other cases in which the pus from a peri-appendicular abscess was evacuated through the mouth. Similar cases have also been recorded by other surgeons.

Subdiaphragmatic abscess is a not infrequent complication of appendicitis. It is, whether developing before or after operation, to be considered rather as a complication of the disease than as a sequel or post-operative complication. It occurred twenty times in 2400 cases, and of these four recovered and sixteen died. Many of these instances were discovered only at necropsy.

Barnard has most thoroughly studied the subject of subdiaphragmatic abscess and found appendicitis responsible in twelve of seventy-six cases. In my own experience the percentage has even been higher. I consider subdiaphragmatic abscess one of the most

frequently overlooked of all the complications of appendicitis.

Barnard states that appendicitis may infect the subdiaphragmatic fossa in four ways:

1. As a part of an acute general peritonitis, but these cases generally are not classed as purely subdiaphragmatic abscess and are not included in the author's statistics.

2. By a more or less slow and direct extension up the lumbar peritoneal fossa from the pelvis.

3. Through the medium of the portal vein, as a part of phlebitis.

4. By lymphatic extension (*a*) up the right retro-peritoneal cellular tissue, or (*b*) up the lymphatics around the deep epigastric artery to the falciform ligament.

The symptoms of subdiaphragmatic abscess are not so definite that diagnosis is always easy. If, however, we bear in mind that it is found as a result of appendicitis practically always in the right side of the abdomen its recognition may not be so difficult. Moreover, in several cases under my observation it has occurred weeks or even months after the primary operation and has been found as a complication of comparatively mild cases of appendicitis. In general we may say that subdiaphragmatic abscess gives the signs of continued infection just as does any other secondary abscess after an operation for appendicitis. In addition we may have tenderness and dullness in the right upper abdominal quadrant or the loin space, and last and most important the signs of pleural involvement at the base of the lung. If subdiaphragmatic abscess is suspected needling is often of value in demonstrating the presence of pus.

The treatment consists in the prompt evacuation of the abscess. This may be approached in three ways:

1. The transpleural route.

2. The subpleural.

3. The abdominal—median epigastric or lumbar as indicated.

The prognosis in subdiaphragmatic abscess must be guarded. With earlier recognition and treatment our results would be vastly improved.

Purulent pleurisy or empyema is usually the result of the extension of a subdiaphragmatic abscess. It may be accompanied by abscess or gangrene of the lung. I have seen the case of a young man

who suffered an attack of acute appendicitis, from which he apparently recovered without an operation. Later his right chest filled with fluid, which aspiration proved to be pus, the sequence of events and the character of the pus indicated that it was probably the consequences of a subdiaphragmatic abscess. A rib was resected and he improved. Still later the sigmoid flexure was perforated and a pelvic abscess evacuated itself through the rectum.

Pneumonia must always be reckoned with as a possible post-operative complication. In a series of 2400 cases of acute appendicitis there were 25 cases of post-operative pneumonia (1 per cent.). Of these, 16 recovered and 9 died. True lobar pneumonia is rarely seen after operation, though it occasionally occurs particularly when operation must be done in the presence of an acute "cold" of the upper respiratory passages. For this reason I always defer operation when the patient is suffering with a cold, unless the condition is urgent. Pulmonary infections after operation are almost invariably of the broncho-pneumonic type and are caused by minute septic emboli obtaining lodgment in the lung capillaries. The bases of the lungs which are so often the seat of hypostatic congestion and atelectasis after long or trying operations or after enforced dorsal decubitus are the most frequent sites of the infection. In extreme cases an entire lobe or lobes may be involved by confluence. A painful pleurisy may complicate the situation. These cases often run a sluggish course without alarming symptoms. At other times extreme toxæmia is present which may end fatally. The treatment is that of pneumonia in general. If possible the patient should be kept in the open air. Support, sedatives or stimulation as needed sum up the indications. Pulmonary embolism rarely occurs.

Pyæmia may follow suppurative appendicitis and its localization may be legion. **Endocarditis, arthritis**, abscesses of the liver, spleen, brain, etc., have been observed as a consequence. **Acute nephritis** of severe type may occur.

Inflammation of the **parotid gland** is another of these manifestations which is sometimes encountered. I have seen one case of bilateral suppurative parotitis in a case of extra-peritoneal appendiceal abscess. D. F. Jones has recorded a remarkable case in which a girl of nineteen years developed double parotitis (non-suppurative) three times as a complication of as many attacks of appendicitis. He

quotes Stephen Paget, who found that of 101 cases of parotitis the records of which he examined, 18 only were due to disease or injury of the alimentary canal, 23 to that of the abdominal wall, 10 to that of the genito-urinary tract, and 50 to disease or temporary derangement of the generative organs. I have encountered several examples of parotitis occurring usually about three days after operation and subsiding without suppuration, but have considered them more in the light of accidental infections of the salivary glands independent of the abdominal lesion. I have also seen the parotid gland suppurate, necessitating incision. In one case the abscess evacuated itself spontaneously into the mouth.

The dryness of the mouth, the stagnation of the parotid secretion during anæsthesia and later by reason of the enforced liquid diet, together with possible injury to the exit of Steno's duct by the fingers of the anæsthetist, are all favoring factors in the production of parotitis should a mouth infection ascend the duct.

Abscess of the abdominal wall consequent upon an appendicitis may occur in rare instances. The following is an illustrative case:

A boy, aged thirteen years, with a history of three attacks of appendicitis, was referred to me by my friend, Dr. P. F. Moylan. During his last attack the boy had been attended by Dr. Moylan, who said to me that at the time of his first visit there was a general peritonitis, which was attended by so much distention that he was unable to make out by examination the cause of the peritonitis. There was apparent recovery after this attack.

At operation, performed by making an incision through the right semi-lunar line, a cheesy mass situated beneath the transversalis muscle was disclosed. The peritoneum beneath this collection had been destroyed and the mass was limited posteriorly by the great omentum. The cheesy material was curetted away and the cavity was antisepticated. The diseased portion of the omentum was ligated from the remaining healthy portion and was excised. The cæcum contained two perforations, which were exposed after the removal of the diseased and adherent omentum. The appendix was post-cæcal and embedded in a mass of coagulated lymph, and was perforated at its base. The pelvis contained a collection of pus, which was limited by adherent coils of intestine.

The patient recovered.

Among the important complications of appendicitis are various lesions of the gastro-intestinal tract.

Obstruction of the intestine consequent upon contraction of peritoneal adhesions is one of the most common. Intestinal obstruction is more frequently encountered after operations in pus cases, but may occur in chronic cases, and in some instances the first symptoms complained of may be those of intestinal obstruction, more or less complete. These peritoneal bands should be sought for, and, if detected, should be divided at every operation for appendicitis. Even when actual strangulation does not exist, the obstruction may be sufficient to cause the most distressing gastro-intestinal symptoms, such as obstinate constipation, flatulency and colic. The obstruction may be due to generalized adhesions, or to a single band beneath which a knuckle of gut becomes constricted. In the former case there is not often strangulation of the bowel, but the gastro-intestinal symptoms above mentioned are almost invariably present. But if the appendix itself, or some distinct peritoneal band, extends from one portion of the abdomen to another, no symptoms of any consequence may arise until suddenly acute intestinal obstruction occurs from the strangulation of the bowel beneath this band. I have seen a case in which a peritoneal band the result of chronic appendicitis was stretched between the appendix and a Meckel's diverticulum. Obstruction resulted from a coil of intestine becoming engaged beneath this band. A case in which the appendix became adherent to the sigmoid flexure, forming a bi-mucous fistula, is referred to at page 21. I have seen intestinal obstruction follow the contraction of the walls of an appendiceal abscess in which the wall of the abscess cavity was made up largely of small intestine.

Among the most intractable accompaniments of appendicitis is **mucous** or **membranous colitis**. In some cases the obtruding symptoms are purely those of the colitis, and the diseased condition of the appendix may be for a long time unsuspected. At times there are also manifestations of indigestion, and at other times the most aggravated neurasthenia. Indeed, it is quite certain that a not inconsiderable percentage of neurasthenics suffer from chronic appendicitis; but as mentioned in the chapter on Chronic Appendicitis, it does not always happen, as in the following case, that removal of the appendix effects a cure of the neurasthenia as well as of the gastro-intestinal symptoms:

Miss P., aged forty-four years, was referred to me with the following history: For the past three years she had suffered from a mucous diarrhoea, which had been attributed by various physicians to enterocolitis, dysentery, etc., and had been treated by the most diverse methods, from bismuth by the mouth to quinine and nitrate of silver by the rectum.

Upon admission to the German Hospital she was markedly neurasthenic and much emaciated. Her bowel movements averaged from four to eight daily. They contained mucus, shreds of mucous membrane, and blood. Upon careful examination the appendix was found enlarged and was painful on pressure; there was no rigidity of the abdominal wall. She gladly consented to operation, in the hope of obtaining relief, and the appendix, when removed, was found to present typically the lesions of catarrhal inflammation. Recovery from the operation was uninterrupted. The bloody and mucous stools, the neurasthenia, and the emaciation, however, did not markedly improve for over three months after the operation, when her symptoms rapidly abated. She gained flesh, and within one year she considered herself entirely cured. The digestive functions were performed normally, the neurasthenia had disappeared, and she had increased in weight over twenty pounds.

The removal of the diseased appendix, which may or may not be the primary cause of a train of symptoms like those just narrated, is of utility only in that it removes a portion, even if it be considered the most important portion, of the cause of the symptoms. The other morbid conditions present will then require treatment, and it is often months or years before decided improvement is manifest. Indeed I have now seen so many cases where the removal of a chronically diseased appendix—one which has never produced acute symptoms—seemed to have absolutely no effect on the neurasthenic and gastro-intestinal symptoms, that I feel very doubtful whether such an appendix may not be considered as much the result as the cause of the disease.

Hernia of some form or variety may complicate an attack of appendicitis, and if the hernia be strangulated, or even if it be only irreducible or inflamed, or if strangulation be suspected, the symptoms of the appendicular inflammation may be entirely obscured, as is illustrated by the following case:

Mrs. X., aged forty-two years, was admitted to the German Hospital and the following history was elicited: Two days prior to admission she had been attacked with general abdominal pain, which was associated with vomiting and marked constipation. The attending physician detected a mass in the right inguinal canal which the patient stated was an old hernia. The mass

was tender on pressure and was irreducible by taxis, even under anæsthesia. The patient steadily grew worse, and the following morning she was again etherized and another futile attempt was made to reduce the mass. She was then removed to the hospital, where I saw her. The mass was tender and was evidently inflamed; the abdomen was distended and the bowels were absolutely constipated; vomiting occurred frequently. Incision over the tumor showed that it was the sac of an old hernia which was not the seat of inflammation. By extending the original wound the peritoneal cavity was opened, and a general purulent peritonitis was disclosed. The appendix which was extensively diseased was removed. The peritoneal cavity was thoroughly irrigated, drainage was introduced, and the wound was closed. The patient did not rally, but died eighteen hours after the operation.

The original site of inflammation was undoubtedly the appendix, but the hernia and the mass to which it gave rise in the right inguinal canal had misled both the attending physician and myself.

Not only may appendicitis be mistaken for a strangulated hernia and *vice versa*, but the appendix may be found in the sac of the hernia, of either the inguinal or femoral variety. It has been observed in left-sided hernias as well as in those on the right, being probably carried into these abnormal positions by the ileum, which is the part of the intestinal tract most frequently found in hernial sacs. The appendix may remain in the sac for years, unattended by symptoms; it may be found, uninflamed, in the midst of strangulated bowel, at a herniotomy; it may become inflamed, and suppuration may occur, in the hernial sac, without there being any strangulation, yet producing symptoms nearly typical of strangulated hernia; or it may be detected only by accident at necropsy, or at operation for the radical cure of the hernia.

Tuberculosis, either latent or active, is a very grave complication of appendicitis. I have frequently been impressed by the fact that in many cases that do badly there is a tuberculous family history, even if no demonstrable tuberculous lesions exist in the patient. The underlying condition may thus be not only one of diminished power of resistance to the influence of agents provocative of acute inflammation, but also, in some instances at least the consequence of dormant tubercle bacilli being roused into activity by the appendicular disease. Be this as it may, the fact is certain that protracted convalescence, the development of multiple abscesses, or of a fæcal fistula, and other debilitating results, are to be greatly feared in the tuberculous subject. Indeed it is questionable, I

think, whether it is always wise to remove an appendix from an undoubtedly tuberculous subject, except for acute disease. Where the disease is chronic, or at most subacute, I think the surgeon will do well to palliate, as any operation on such subjects is liable to rouse into activity dormant tuberculous processes; and the exchange of a semi-quiescent appendix for a persistent fæcal fistula or active tuberculosis elsewhere will be most unsatisfactory to all concerned. I have seen a number of such results which were unavoidable, as operation was undertaken for the evacuation of appendiceal abscesses; but where an operation is not imperative, temporizing will as a rule be more to the interest of the patient.

Finally, extremely important complications and sequels of appendicitis are certain **diseases of the female genitalia**. Appendicitis of every variety has been found associated with almost every pathological condition of the pelvic organs. The sequence of events varies in different cases; at times the lesions commence in the appendix and subsequently involve the genitalia; at other times the inflammatory phenomena are inaugurated in some portion of the genitalia and later implicate the appendix. From rather extensive observation it has seemed to me that the former is not at all uncommon, (1) because widespread pelvic lesions are not likely to be encountered in young women and girls in whom no history or sign of external infection can be detected; (2) because of the excessive virulence of appendicular pus and the especial faculty it possesses of inaugurating purulent processes in other portions of the body; (3) because the right tube may be markedly involved and adherent to the appendix while the left tube is normal, and (4) because the initial symptoms point rather to disease of the appendix than to disease of the genitalia. Although the diseased processes in individual cases may commence in the genitalia, the manifestations of appendicitis may be so prominent that the symptoms of uterine, tubal, or ovarian disease are obscured, and are revealed only by operation or necropsy.

When a peri-appendicular abscess occupies the pelvis it usually results from an ulcerative or gangrenous inflammation of an appendix that points due south or southeast. In these cases the distal extremity only of the organ may be affected, but it is usually in close relationship with one of the pelvic organs. The pain in these cases

is usually left sided, and the abscess formed is of moderate size only. For these reasons there is great liability of confounding the conditions with disease of the pelvic organs, and errors in diagnosis are rendered still more likely because of the rapid formation of firm adhesions that limit the abscess to the immediate vicinity of the sigmoid flexure, the rectum or the bladder. The bladder and sigmoid flexure may be perforated. Two cases of this character have already been referred to.

Special emphasis must therefore be directed to the clinical importance of these pelvic lesions—conditions in which both the tubes and ovaries, together with the appendix, are involved in phlegmonous inflammation. Surgically they may present difficulties that are insurmountable. The various organs are covered by great masses of fibrinous or fibrino-purulent exudate in which one or more abscesses may be encountered. There are also found dense adhesions that have so devitalized the tissues that the slightest traction is likely to lead to rupture of the bladder or the intestine.

These conditions not only possess a present danger, but also a most serious remote danger, in that they exhibit a most persistent tendency to recur, a tendency which it is sometimes beyond the power of human skill to overcome. As already mentioned, intestinal obstruction and strangulation may ensue. In addition, the omentum frequently becomes attached to the parietal peritoneum, and, by its efforts to free itself, as well as by certain of the patient's movements, such as coughing, sneezing, deep inspirations, etc., intense pain may be provoked. Indeed, in some cases even slight adhesions are sufficient to constitute a source of considerable trouble and complaint.

Pregnancy also may complicate appendicitis, and *vice versa*, and is always a cause of anxiety. If appendicitis occurs during the early stages of gestation, abortion frequently results. In any case a pregnant woman who is attacked by acute appendicitis should be operated upon as soon as practicable after the onset of the initial pain. The removal of a diseased appendix during pregnancy is attended by few if any risks to either mother or fœtus, apart from those dangers that may attend any operation. The usual risks, on the other hand, that accompany the non-removal of an inflamed appendix, in every case, are much increased by the pregnant state, and the evil consequences of a subsequent attack of appendicitis, with

perhaps perforation and gangrene, are correspondingly augmented. A recurrent attack with pus formation may occur at a later stage of the same pregnancy when the dangers of operation and miscarriage may be considerably greater than in the early stages. I have seen a number of cases of appendicitis in pregnant women in whom, as a consequence of delay in operation, the right uterine adnexa have become infected, and most serious conditions—in some instances death—have ensued. The earlier the operation, the less the likelihood of infection of the right tube and ovary, and the less likely, therefore, the development of serious complications. The wisdom of early operations is especially evident from the fact that I have never had abortion to occur in pregnant women upon whom I have operated for acute appendicitis unless the right uterine appendages were involved in the disease and seldom then. Appendicitis also may complicate parturition and the puerperium, and in either condition is of serious moment. The establishment of a differential diagnosis between ante-partum or post-partum sepsis and appendicular sepsis will often tax the resources of the most erudite and experienced. The havoc which may result from suppurative pelvic appendicitis in a young girl is appalling.

POST-OPERATIVE COMPLICATIONS OF ACUTE APPENDICITIS.

	German Hospital	Children's Hospital	Total
Number of cases reviewed.....	1997	403	2400
Number of complications.....	236	90	326
Number of deaths.....	77	23	100
Number of recoveries.....	159	67	226

Acute Dilatation of Heart

Cases.....	4
Death.....	4

Abscess, Secondary

Cases.....	47
Recovery.....	34
Death.....	13

Abscess, Sub-phrenic

Cases.....	20
Recovery.....	4
Death.....	16

Anuria

Cases.....	1
Recovery.....	1

Abscess, Peri-splenic		Evisceration from Crying	
Cases.....	1	Cases.....	2
Death.....	1	Recovery.....	2
Apoplexy		Fæcal Fistula	
Cases.....	1	Cases.....	42
Recovery.....	1	Recovery.....	36
Bronchitis		Death.....	6
Cases.....	6	Closed spontaneously.....	28
Recovery.....	6	Closed by operation.....	4
Cerebral Embolism		Persisted.....	4
Cases.....	2	Fistula in Ano	
Recovery.....	1	Cases.....	1
Death.....	1	Recovery.....	1
Cystitis		Furunculosis	
Cases.....	2	Cases.....	1
Recovery.....	2	Recovery.....	1
Delirium Tremens		Gangrene of spleen.....	1
Cases.....	7	Gangrene of ileum.....	1
Recovery.....	4	Death.....	2
Death.....	3	Hæmorrhage	
Diarrhœa		Cases.....	1
Cases.....	2	Death.....	1
Recovery.....	1	Hæmorrhage, Secondary	
Death.....	1	Cases.....	2
Diphtheria		Recovery.....	1
Cases.....	2	Death.....	1
Recovery.....	2	Hernia	
Edema of Lungs		Cases.....	3
Cases.....	4	Recovery.....	3
Death.....	4	Hiccough	
Endocarditis		Cases.....	1
Cases.....	2	Recovery.....	1
Recovery.....	2	(coughed wound open)	
Epididymitis and Orchitis		Intestinal Obstruction	
Cases.....	2	Cases.....	33
Recovery.....	2	Recovery.....	23
Enteric Fever		Death.....	10
Cases.....	3	Insanity, Post-operative	
Recovery.....	3	Cases.....	1
Erysipelas		Recovery.....	1
Cases.....	2	Influenza	
Recovery.....	2	Cases.....	1
		Recovery.....	1

Ischio-rectal Abscess		Pulmonary Embolism	
Cases.....	1	Cases.....	5*
Recovery.....	1	Recovery.....	1
		Death.....	4
Measles		Relaxed Sphincter	
Cases.....	2	Cases.....	1
Recovery.....	2	Recovery.....	1
Melaena		Retention of Urine	
Cases.....	2	Cases.....	3
Recovery.....	2	Recovery.....	3
Necrosis of the Bowel		Rheumatism	
Cases.....	19	Cases.....	1
Recovery.....	12	Recovery.....	1
Death.....	7	Salpingitis	
Nephritis		Cases.....	4
Cases.....	3	Recovery.....	4
Recovery.....	3	(Operation 2nd)	
Otitis Media		Scarlatina.....	1
Cases.....	1	Recovery.....	1
Recovery.....	1*	Scarlet Fever	
Parotitis		Cases.....	1
Cases.....	3	Recovery.....	1
Recovery.....	3	Sinus Persistent	
Peri-rectal Abscess		Cases.....	1
Cases.....	1	Recovery.....	1
Recovery.....	1	Shock	
Pertussis		Cases.....	1
Cases.....	1	Death.....	1
Recovery.....	1	Sub-phrenic, Sub-diaphragmatic	
Phlebitis		Abscesses	
Cases.....	4	Cases.....	20
Recovery.....	4	Recovery.....	4
Pleurisy		Death.....	16
Cases.....	8	Tonsillitis	
Recovery.....	8	Cases.....	3
Pneumonia		Recovery.....	3
Cases.....	25	Ulcer decubitus	
Recovery.....	16	Cases.....	1
Death.....	9	Recovery.....	1
(includes one of tuberculosis)		Uræmia	
		Cases.....	2
		Death.....	2

APPENDIX

THE MEDICAL TREATMENT OF APPENDICITIS

Medical treatment should not be used in appendicitis except as directed below.

Under ideal conditions the rôle of the physician in acute appendicitis is to make the diagnosis and to impart his knowledge of the condition to the patient or his family with the strongest recommendation that the surgeon be called and the case placed in his charge as expeditiously as possible. It must be recognized, however, that under the many and varied conditions of practice in which so frequent a disease may be encountered, it is not always possible to meet the requirements of ideal treatment. Therefore, a brief consideration of this important subject from the standpoint of the general practitioner may not be out of place.

It must be thoroughly understood that any deviation from the principle of immediate operation can be justified only by circumstances which are beyond the control of the physician. It occasionally happens that the prejudice against surgery on the part of the patient or his responsible relatives will cause him to decline to act upon the recommendation of the physician. In the present state of education of the laity in respect to this disease it is rare to meet such a refusal. Of late years, indeed, it has been my experience to find more often the reverse condition, namely, the patient insisting upon operation in the face of the too optimistic physician who is willing to temporize with medical measures. Occasionally there may exist relative or absolute contraindications to operation which make its performance at the time, or at any time, inadvisable. As absolute contraindications may be instanced the presence of broken cardiac compensation, of pneumonia or any general disorder which is acutely threatening to life. Relative contraindications are to be found chiefly in the presence of chronic disease of the heart, lungs or kidneys, or the less severe general disorders, which, while not necessarily immediately threatening to

life, are yet of such a character as to be unfavorably influenced by the performance of an operation.

Surgical advice is to be sought in these cases just as in those where operation is clearly indicated, since the surgeon is necessarily better informed as to the relation of general disease to operation.

There are some localities where a surgeon is not available and many where more or less delay is unavoidable before operation can be performed. "It must be insisted that the abdomen should not be opened by the family physician, unless he is a skilled surgeon. In these days of rapid transportation a surgeon can soon reach the patient. An operation for appendicitis by an unskilled man would have more risks to the patient than delay" (Fussell). In the majority of cases the patient looks to the physician for some sort of treatment prior to the arrival of the surgeon, and not infrequently in cases where the diagnosis is not at once clear, the physician is obliged to institute treatment which will at least satisfy the mind of the patient during the period of doubt as to the true diagnosis. The necessity for beginning treatment in the very early stages of the disease before a diagnosis is made between appendicitis and simple colic or gastro-enteritis or one of the many other painful abdominal affections has been responsible for many fatalities. Certainly every effort should be made to differentiate these conditions, which may usually be done by observing carefully the points already mentioned in the chapter on differential diagnosis. Still, occasional cases will be encountered which cannot at once be correctly diagnosticated. A certain period of observation becomes necessary and it is during this time that the most flagrant errors are committed in the treatment of the case should it prove to be appendicitis. The physician who sees many minor ailments is rather too free to assume that the doubtful case is one of simple colic and indigestion to be treated by a purge with an anodyne if pain is prominent. I have no hesitation in saying that to these two factors, purgatives and anodynes, may be attributed the greater part of the mortality due to acute appendicitis. This unenviable eminence is earned by anodynes through the part they play in obscuring diagnosis, allaying the alarm of patient and physician and thus delaying operation, delay being the most important single

cause of death from this disease. Purgatives if given with intention or in the misguided belief that the condition is other than appendicitis hastens inflammation, suppuration and perforation of the appendix itself and disseminates peritonitis. Therefore the principle may be laid down that in case of doubt as to the existence of an acute surgical condition it is safer to institute treatment under the presumption that the surgical condition is present, since much harm may be done by ill-advised medication and improper handling of the early stages of acute surgical disease of the abdomen, while delay in beginning treatment rarely influences the outcome of medical conditions.

The most important points to be observed in the suspected presence of acute appendicitis are negative rather than positive and consist in the prohibition of everything by mouth, including water, and especially the avoidance of all purgative medicine. Morphia and other anodynes should be avoided until the diagnosis or indications for treatment become clear. When peritonitis is suspected the sitting position should be adopted at once. Ice bags may be placed over the abdomen, or hot applications if they are desired and prove to be more comforting to the patient. A small simple enema should be given, following which, continuous or intermittent proctoclysis should be begun. By this treatment the diagnosis will not be obscured and in the event of acute appendicitis even if it progresses to gangrene, perforation, or spreading peritonitis, the patient will be given the best chance for recovery either with or without operation.

When the diagnosis of acute appendicitis is established, if a considerable interval must elapse before operation can be done the measures to be employed may be summarized as: (1) sitting posture; (2) prohibition of *all* medicine, food or drink by mouth; (3) gastric lavage, particularly if a meal has just been taken or if vomiting is a feature; (4) ice bags on the abdomen; (5) proctoclysis; (6) avoidance of anodynes, except in the presence of severe pain or restlessness, when a small dose of morphia is permissible. These measures are simple applications of the principles of anatomic and physiologic rest, upon which the entire medical treatment of appendicitis depends. Their rationale has already been sufficiently discussed in the chapter on Surgical Treatment. In the minor

attacks or exacerbations of the disease such treatment may seem unduly rigid and severe, yet such is the insidious character of the disease that it is best to follow closely the plan outlined, since this is in itself not only harmless but actually beneficial, while if neglected the consequences in a percentage of cases will be most disastrous.

A patient so treated will be brought to the surgeon in the best possible condition for operative treatment. If for any unavoidable reason operation cannot be done the same measures should be carried out during the subsequent course of the disease which commonly eventuates in several well-known ways which cannot, however, be foretold for the individual patient. Many cases will subside and recover from the acute attack, bearing, however, as a rule, adhesions, torsions, angulations or cicatrices of the appendix which predispose to subsequent attacks. At times diffusing peritonitis will progress to general involvement producing overwhelming toxæmia and death. If the line of treatment indicated be carefully followed out, general peritonitis will rarely result. More often the process will be arrested and the inflammation localized about the appendix forming a periappendicular abscess. There is no medical treatment for this condition and while in an occasional fortunate case such an abscess may rupture into the bowel or through the parietes and thus discharge itself, this is an exceedingly rare occurrence and to refuse operation in such a condition is usually synonymous with suicide. There is no contraindication, either relative or absolute, that should deter the surgeon from the attempt to open a periappendicular abscess.

Ordinarily, alimentation is not a factor to be considered during the period preliminary to operation. If that period be unduly prolonged, or in the absence of operation, rectal feeding may be tried. Alcohol in the form of a small dose of brandy or whiskey given with the saline solution by bowel is absorbable and of some value as a food. Dextrose also is available and may be used to replace the salt in making the solution isotonic. Predigested beef juice or milk are also of some service. The usual complex, flavored and undigested foods given by rectum are useless or worse. The taking of food or fluid by mouth is to be postponed until peritonitis, if present, has subsided and peristalsis is resumed.

In the cases not suitable for operation drugs may be employed

during the course of the disease for their stimulant or sedative effect as symptomatically required. Extreme pain demands opium carefully administered, care being taken that the patient is not narcotized. For distention, turpentine stupes, stimulant enemata, the insertion of the rectal tube, asafœtida suppositories, and finally eserine and strychnia hypodermically may be employed, though the paralytic distention due to sepsis is but little influenced by any of these measures, while mechanical ileus responds not at all.

In conclusion it may be stated that the only legitimate field for the so-called Medical Treatment of Acute Appendicitis is as a preliminary to operation which should not be delayed thereby; that in this period the chances of recovery are much affected by the measures adopted by the physician; that medical treatment of appendicitis throughout its course is justifiable only by rare and special conditions; that its outcome is problematical but the outlook may be improved by rational therapy conducted along the lines of anatomic and physiologic rest.

The ideal treatment of chronic appendicitis, just as in the acute form of the disease, is operation. Obviously, however, the necessity for haste is less pressing. Ample time may be given to the preparation of the patient for operation. The mouth and teeth should be brought into good condition. The diet and bowels should be carefully regulated. The activity of the skin and kidneys should be assured. Excesses of whatever nature should be curtailed and in short every hygienic measure should be employed in order that the health and the resistance of the patient may be at the highest point when operation is performed.

The simple removal of a chronically diseased appendix as done by an experienced surgeon upon a patient in ordinarily good health is an operation that is almost devoid of mortality. It is not to be compared in point of danger to the harboring of a diseased appendix, which we know in a large percentage of cases gives rise sooner or later to an acute attack. The physician's advice to the patient, therefore, should be based upon this fact. If operation is not accepted by the patient it should be with the full knowledge of the risk that he thereby assumes and with the full appreciation of the fact that no form of medical treatment will provide security against an acute attack.

There are circumstances which justify postponement of operation if the patient be within easy reach of a surgeon and understand the importance of immediate operation in case acute symptoms arise. In no case should a person who is the subject of chronic appendicitis permit himself to be at such a distance from a competent surgeon that operation could not be done in the event of an acute attack.

There is no medical treatment of chronic appendicitis aside from the requirements of general hygiene.

The interval operation for appendicitis, about which one formerly heard much, has been relegated to a deserved oblivion. The term "interval operation" implies improper treatment, since no one, unless under very exceptional circumstances, should be allowed to have more than the first attack, as the appendix should have been removed early in that attack. The idea of attempting to carry a case of acute appendicitis through an acute attack by medical means in order that the appendix may be removed more safely after the subsidence of acute symptoms is an absurdity. In case an abscess has been present at the time of operation and the surgeon has found it impossible or imprudent to remove the appendix it is proper and advisable to remove the appendix after recovery from the abscess has taken place. The appendix is rarely if ever completely destroyed during the process of abscess formation and in a considerable percentage of cases gives subsequent trouble. In this sense the interval operation still has a field of usefulness.

Finally, it should be remarked that any symptoms due to disease of the appendix, however slight, are a distinct warning and constitute the indication for appendectomy; that medical treatment has but an insignificant influence in warding off attacks as can be understood by anyone who has the least knowledge of the pathology of the disease; that the operation of simple appendectomy has almost no contraindications owing to the very slight mortality attached to it; and that the patient is fortunate to have his disease begin in a chronic rather than in an acute form if he fall into the hands of an enlightened physician who thoroughly understands the possibilities and limitations of medical versus surgical treatment of appendicitis.

LIST OF NAMES.

Aboulker, 116
 Adami, 148
 Adenot, 28
 Adrian, 75
 Ahrt, 21
 Albers, 23
 Amyand, 14 30
 Anders, 334
 Amick, 203
 Apolant, 75
 Aretæus, 10, 29
 Arnaldus Villanovanus, 10
 Aschoff, 163
 Ashhurst, 207
 Aufrecht, 139
 Avicenna, 10

Baglivus, 14
 Baillie, 16
 Baldauf, 121
 Barbacci, 150
 Barnard, 342
 Barth, 116
 Battle, 282
 Bauhin, 6
 Beger, 123
 Bennet, 181
 Berard, 337
 Berardinone, 188
 Berengarius, 4
 Berry, 42, 64, 157, 162, 333
 Bertel, 123
 Bierhoff, 26
 Birch-Hirshfeld, 165
 Blackadder, 17
 Blake, 52
 Bland-Sutton, 70, 108
 Bloodgood, 79
 Blumer, 69, 197
 Bodey, 19
 Boerhaave, 14, 30
 Boody, 52

Borst, 123
 Bossard, 96
 Box, 77
 Boyer, 20
 Brazil, 77
 Breuer, 160
 Brewer, 246
 Briquet, 24
 Bristow, 47
 Bryant, 43
 Buck, 35
 Bull, 138
 Burkhardt, 123
 Burne, 22

Cabot, A. T., 123
 Canal, 67
 Celsus, 9, 10
 Chapple, 223
 Chaput, 37
 Chassaignac, 35
 Clado, 9, 39
 Cless, 25
 Coats, 108
 Coe, 72
 Copeland, 16
 Copland, 20
 Corbin, 23
 Corner, 248
 Crellius, 15
 Crile, 205
 Cushing, 202
 Czerny, 115

Dalmer, 96
 Dance, 18
 Davis, 37
 Dawbarn, 37, 289
 Day, 118
 Deaver, H. C., 196, 231
 Deaver, J. B., 37, 78, 107
 Dennis, 197

- Dietrich, 123
 Dieulafoy, 173, 234
 Dixon, 197
 Dodwell, 113
 Dudgeon, 152
 Dun, 197, 221
 Dupuytren, 20
 Durand, 58

 Edebohls, 39, 165, 238
 Edington, 123
 Einhorn, 70, 138
 Elliot, 37
 Erastus, 12, 13
 Ewald, 103

 Fabricius ab Aquapendente, 7
 Fabricius Hildanus, 12
 Fallopius, 6
 Fenwick, 108, 113
 Fernelius, 11
 Ferrall, 19
 Finney, 77, 202
 Fitz, 26, 202
 Fowler, Geo. R., 38, 159
 Fowler, R. S., 38
 Fox, 26
 Fraenkel, 108
 Franke, 74, 221
 Frankfurter, 132
 Frazier, 173
 v. Frisch, 146

 Galen, 1, 10
 Garmanns, 15
 Gaut, 334
 Gerlach, 9, 54
 Gerster, 339
 Gibson, 255
 Goetjes, 123
 Goldbeck, 19
 Goluboff, 174
 Goodhart, 76
 Gouillioud, 28
 Goyens, 197
 Grant, 76
 Green, 203
 Grill, 114
 Grisolle, 23

 Guinon, 248
 Guttman, 108

 Haedeus, 115
 Haig, 77
 Haller, 8, 16
 Hallowell, 23
 Hamburger, 77
 Hammond, L. J., 202
 Hancock, 33
 Harte, 117, 207
 Hawkins, 103, 108, 158
 Head, 181
 Heister, 15
 Helmont, 13, 29
 Herlin, 16
 Hermes, 70
 Hildebrandt, 185
 Hilton, 214
 Hinglais, 114
 Hippocrates, 9
 Hoefer, 67
 Hoffacker, 21
 Holden, 43
 Homans, 35
 Hoffenhausen, 201
 Hornung, 23
 Husson, 18
 Hyde, 152

 Iliff, 19

 Jacobson, 77
 Jadelot, 16
 Jalaguier, 282
 Jobert, 18
 Jones, 122, 339, 344
 Jopson, 101
 Josue, 173

 Kahn, 184
 Kammerer, 282
 Karrenstein, 72
 Keen, 96
 Keetley, 334
 Kehr, 234
 Keith, 67
 Kelly, 116, 117
 Kelynack, 75, 103, 108, 157

- Klecki, 174
Krafft, 138, 156
Kraussold, 103
Kretz, 75
Krönlein, 35
Kümmel, 132
- Lack, 157, 163
Lafforgue, 116
de Lamotte, 16
Lane, 222
Langheld, 138
Lanz, 150
Laurentius, 6
Le Conte, 123
Leichtenstern, 146
Lejars, 121
Lennander, 132
Letulle, 86
Leube, 107
Leudet, 25
Lewis, 34
Lieberkühn, 8
Lockwood, 9, 54, 61
Louyer-Willermay, 17, 21
Lowe, Peter, 12
- McBurney, 27, 37
MacCarty, 118
McCosh, 196, 221
MacEwen, 67, 316
McGrath, 118
Mackenzie, 61
McRae, 70
McWilliams, 117, 122, 223
Malespine, 24
Mangoldt, 189
Manley, 69
Mannaberg, 189
Marvel, 75
Maschowitz, 119
Mathes, 221
Matterstock, 26
Maunsell, 193
Mayer, 76
Mayo, 38
Melier, 18
v. Merling, 21
Mestivier, 15, 32
- Metchnikoff, 67
Mikulicz, 140
Milner, 118, 123
Monks, 52
Morgagni, 7
Morton, T. G., 36
Mounier, 116
Morris, 224
Moylan, P. F., 345
Moynihan, 38, 225
Moxon, 26
Münchmeyer, 35
Muscatello, 56
Murphy, 115, 210, 214, 254
Mannings, 156
- Navratil, 127
Neilson, 251
Neugobauer, 108
Noeggerath, 86
Nothnagel, 103
Noyes, 35
- Oberndorfer, 118
Ochsner, 38, 183
Oppolzer, 25
Oribasius, 10
Ormerod, 25
Orth, 123
- Page, 108
Paget, 345
Paré, 4
Parker, Willard, 34
Parkinson, 16
Partsch, 116
Paterson, 328
Paulier, 138
Paulus, Simon, 11
Paviot, 77
Pedrini, 29
Pellegrini, 339
Pepper, Wm., 26
Perrone, 201
Petrequin, 20, 23
Pevvel, 337
Pieron, 21
Piersol, 162
Pilcher, 96

- Polya, 127
 v. Pommer-Esche, 23
 Ponceau, 18
 Poynter, 77
 Prescott, 17

 Rammstadt, 79
 Reichel, 184
 Renvers, 132
 Rhea, 118
 Ribbert, 157, 162
 Richardson, 186
 Riedel, 198, 234
 Riverius, 30
 Robinson, Byron, 52, 70, 164
 Robson, 38, 225
 Roberts, John B., 203
 Rodman, 334
 Roger, 173
 Rogers, 232
 Rokitansky, 24
 Rolleston, 9, 61, 122, 181, 248
 Rostowzen, 75
 Roussel, 13
 Roux, 132, 173
 Rowntree, 115
 Ruhräh, 114
 Russ, 333
 Ruyschius, 14

 Sabatier, 8
 Sahli, 157
 Sailer, 316
 Sands, 36
 Santorini, 8, 14
 Saracenus, 12
 Sargeant, 152
 Schede, 126
 Schelbenzuber, 337
 Scholler, 165
 Schrumpf, 116
 Schüller, 36
 Senn, 28, 111
 Shaw, 69, 197
 Sherren, 59, 181
 Singer, 223, 234
 Sonnenberg, 70, 78, 138
 Sprengel, 37
 Stengel, 108

 Stephanus, 4
 Sternberg, 123
 Stokes, 203
 Sutherland, 76
 Swallow, 108
 Sydenham, 13, 30
 Symonds, 18, 35

 Tait, 36
 Talamon, 70, 83
 Tavel, 150
 Tiedemann, 21
 Tietze, 144
 Toft, 103
 Treitz, 9
 Treves, 36, 108
 Tripier, 77
 Tulpus, 6
 Tuttle, 333

 van Cott, 159
 Vassmer, 118
 Verheyen, 7
 Vesalius, 4
 Vidus Vidius, 6
 Virchow, 107
 Voeckler, 121, 123
 Volz, 25, 168
 Vosse, 8

 Waldron, 19
 Wallace, 77
 Walther, 25
 Waring, 115
 Warthin, 119, 122
 Weber, 76
 Wedels, 15
 Wegeler, 17
 Weir, 35, 108, 123
 Weitbrecht, 8
 Welch, 150
 Werth, 108
 Whipham, 123
 White, 123
 Whitmore, 333
 Wickham, 18
 Wilks, 26
 Willis, 14
 Willy Meyer, 333
 Wilms, 316

List of Names

365

With, 26

Wood, 67

Woolsey, 43

Wright, 124

Yeo, 77

Zacutus Lusitanicus, 29

Zuckerhandl, 162

INDEX.

- Abdominal belts, 313
 - supporters, 313
 - tonsil, 42
 - wall, abscess, 345
- Abscess, abdominal wall, 345
 - after-treatment, 330
 - appendicular, 89
 - follicular, 90
 - in children, 98
 - interstitial, 89
 - diagnosis, 215
 - diffuse, 136
 - hepatic, 139, 236
 - kidney, 139, 239
 - liver, 139, 236
 - omentum, 302
 - operation for, 290
 - ovarian, 245
 - para-typhlitic, 136
 - peri-appendicular, 133, 289
 - absorption, 139
 - position, 135, 289
 - rupture, 138
 - sequels, 139
 - peri-hepatic, 236
 - peri-renal, 137, 242
 - peri-typhlitic, 133
 - peritonæal, 312
 - pulmonary, 137, 139
 - retroperitoneal, 96, 137
 - secondary, 300
 - spleen, 139
 - stitch, 313
 - subdiaphragmatic, 137, 342
 - subphrenic, 137, 342
- Absence of appendix, 42
- Actinomycosis in appendicitis, 78, 114
- Adhesions, peritoneal, 144
 - post-operative, 316
 - treatment, 317
- Ætiological factors, actinomycosis, 78
 - age, 69
 - table, 71
- Ætiological factors, bacteria, 146
 - blood supply of appendix, 159
 - calculi, 165
 - chemical irritation, 164
 - chicken-pox, 77
 - concretions, 165
 - constipation, 73
 - disturbance of digestion, 77
 - drainage of appendix, 153, 155
 - dysentery, 74
 - enterozoa, 165
 - exciting causes, 164
 - exposure to weather, 78
 - foreign bodies, 165
 - gastro-enteritis, 73
 - Gerlach's valve, 156
 - influenza, 75
 - intestinal parasites, 79
 - involution of appendix, 162
 - length of appendix, 156
 - lymphoid tissue, 157
 - measles, 77
 - meso-appendix, 155
 - mixed infection, 150
 - nationality, 72
 - predisposing causes, 155
 - previous attacks, 77
 - purpura hæmorrhagica, 77
 - recapitulation, 170
 - rheumatism, 76
 - scarlet fever, 77
 - season, 73
 - table, 71
 - sex, 70
 - table, 71
 - staphylococci, 152
 - streptococci, 152
 - stricture of appendix, 157
 - tonsillitis, 75
 - traumatism, 78, 164
 - tuberculosis, 78
 - typhoid fever, 74
- After-treatment, 323 (vide Operation)

- Age in appendicitis, 69
 table, 71
- Amputation of appendix, spontaneous,
 100
- Anæsthesia, 279
- Anæsthetic, 279
- Anæsthetist, 280
- Anatomy, 41
 comparative, 42
- Angina of appendix, 157
- Anodynes in treatment, 273
- Apophysitis, 27
- Appendicitis, acute, 81, 83
 bacteria, table, 147
 calculi, table, 166
 catarrhal, 81, 83
 macroscopy, 84
 microscopy, 85
 diagnosis, 209
 gangrenous, 81, 99
 macroscopy, 99
 microscopy, 101
 interstitial, 81, 87
 macroscopy, 90
 microscopy, 88
 pain, 176
 reflex symptoms, 182
 rigidity of muscles, 179
 symptomatology, 175
 symptoms, 176
 tenderness, 179
 three cardinal symptoms, 176
 treatment, 264
 ulcerative, 81, 92
 macroscopy, 92
 microscopy, 97
 varieties, 81
- ætiological factors, actinomycosis,
 78
 age, 69
 table, 71
 bacteria, 146
 blood supply of appendix, 159
 calculi, 165
 chemical irritation, 164
 chicken-pox, 77
 concretions, 165
 constipation, 73
 disturbance of digestion, 77
- Appendicitis, ætiological factors, drain-
 age of appendix, 153, 155
 dysentery, 74
 enterozoa, 165
 exciting causes, 164
 exposure to weather, 78
 foreign bodies, 165
 gastro-enteritis, 73
 Gerlach's valve, 156
 influenza, 75
 intestinal parasites, 79
 involution of appendix, 162
 length of appendix, 156
 lymphoid tissue, 157
 measles, 77
 meso-appendix, 155
 mixed infection, 150
 nationality, 72
 predisposing causes, 155
 previous attacks, 77
 purpura hæmorrhagica, 77
 recapitulation, 170
 rheumatism, 76
 scarlet fever, 77
 seasons, 73
 table, 71
 sex, 70
 table, 71
 staphylococci, 152
 streptococci, 152
 stricture of appendix, 157
 tonsillitis, 75
 traumatism, 78
 tuberculosis, 78
 typhoid fever, 74
- ætiology, 69
 bacteria, 80
 bacteriology, 146
 blood changes, 252
 carcinoma, 119
 catarrhal, hæmorrhagic, 85
 purulent, 85
 chronic, 81, 189
 bacteria, table, 147
 catarrhal, 81, 104
 macroscopy, 104
 microscopy, 105
 diagnosis, 191
 indigestion, 193

- Appendicitis, chronic, interstitial, 81, 105
 macroscopy, 105
 microscopy, 109
 obliterating, 81, 111
 macroscopy, 111
 microscopy, 112
 pain, 193
 pathology, 102
 position of appendix, 192
 symptomless, 193
 symptoms, 190
 referred, 193
 treatment, 195
 varieties, 81
 classification, 80
 pathologico-anatomical, 81
 constipation in, 335
 complications, 335
 abscess, abdominal wall, 345
 hepatic, 338
 lung, 343
 pancreas, 336
 peri-appendicular, 341
 subdiaphragmatic, 342
 arteritis, 337
 colitis, 346
 diseases of female genitalia, 349
 empyema, 343
 hernia, 347
 necrosis of intestines, 336
 vessels, 337
 obstruction of intestine, 346
 parotitis, 344
 perforation, 337
 peritonitis, 335
 phlebitis, 337
 pleurisy, 343
 pneumonia, 344
 post-operative, table, 351
 pregnancy, 350
 pyemia, 344
 pylephlebitis, 338
 pyoptysis, 341
 thrombosis, 337
 tuberculosis, 348
 venous, 337
 diagnosis, 209
 earliest case, 12
 exciting causes, 69, 77, 164
- Appendicitis, "frozen out," 271
 fulminating, 100
 gangrenous, 99
 history, 1
 hysterical mimicry, 103
 in children, 196
 abscess, 198
 ætiology, 197
 concretions, 198
 differential diagnosis, 199
 in children, fever, 198
 gangrenous, 198
 pain, 198
 pathology, 197
 perforation, 198
 prognosis, 200
 rigidity, 198
 sex, 197
 symptomatology, 198
 tenderness, 198
 treatment, 200
 infective, 82
 interstitial, 88
 iodine reaction, 257
 larvata, 103
 leucocytosis, 252
 table, 256
 mild, 82
 obliterating, 107, 111
 operation, after treatment, 323
 pain, referred, 59
 pathogenesis, 69, 154
 pathology, 80
 perforating, 82
 predisposing causes, 69
 prenatal, 69
 prognosis, 258
 recurrent, 191
 recurring, 82, 105
 relapsing, 82, 105, 190
 sequels, 335 (vide complications).
 simple, 82
 treatment, history, 28
 post-operative, 323
 typhoid, 97, 201
 diagnosis, 202, 203
 differential, 204
 intestinal hæmorrhage, 206
 perforation, 205

- Appendicitis, typhoid, prognosis, 206
 symptoms, 204
 treatment, 207
 urine, 237
 Appendicostomy, 333
 Appendicular abscess, 89
 follicular, 90
 in children, 98
 interstitial, 89
 colic, 167
 dyspepsia, 193
 Appendiculo-ovarian ligament, 47, 58
 Appendix, abscess, follicular, 90
 interstitial, 89
 absence of, 42
 actinomycosis, 114
 anatomy, 41
 history, 4
 angina, 157
 blood supply, 56
 cæcal attachment, 43
 calculi, 95
 carcinoma, 117
 age, 118
 benignancy, 121
 location, 120
 malignancy, 121
 sex, 120
 with appendicitis, 119
 coats, 54
 colloid degeneration, 107
 concretions, 95
 cysts of, 67
 cystic dilatation, 107
 diameter, 43
 diverticula, 108
 embryology, 41
 empyema, 91
 endothelioma, 123
 fibro-myoma, 116
 functions, 66
 gangrene, 58, 99
 hiatus muscularis, 55
 histology, 54
 hydatid cyst, 116
 hydrops, 107
 intussusception, 248
 length, 43
 lesions of, 83
 Appendix, lipoma, 116
 lymph-adenoma, 116
 lymphatics, 58
 lymph gland, 58
 lymphoid tissue, 66
 lympho-sarcoma, 124
 mucocele, 107
 mucous membrane, 54
 muscular coat, 55
 myoma, 116
 myxo-sarcoma, 126
 nerves of, 59
 perforation of, 58, 93, 95
 peritoneal coat, 55
 polyp, 116
 position, 45, 47
 table, 53
 pseudo-cyst, 108
 purulent infiltration, 89
 retention cyst, 107
 sarcoma, 124
 sloughing, 100
 spontaneous amputation, 100
 submucosa, 55
 suppuration, 89
 tuberculosis, 113
 tumors, 116
 valve, 54
 veins, 58
 Bacillus capsulatus, 152
 coli communis, 148
 enteritidis, 148
 fusiformis, 152
 lactis ærogenes, 148
 neapolitanus, 148
 proteus, 152
 pyocyaneus, 152
 in abscess, 135
 pyogenes fœtidus, 148
 subtilis, 152
 Bacteria as ætiological factor, 146
 colon group, 148
 in appendicitis, 80
 in peritonitis, 128
 table of, 147
 Bacteriology of appendicitis, 146
 Bacterium coli commune, 148
 as a group, 149

- Bacterium coli commune, virulence, 149
 Battle's incision, 37
 Belt, abdominal, 313
 Biliary ducts, diseases, 234
 Bimucous fistula, 96
 Bladder symptoms in appendicitis, 183
 Blood changes in appendicitis, 252
 Bowel necrosis, 336
 Cæcal vein, 58
 Cæcum, carcinoma of, 227
 development, 42
 distention, 223
 embryology, 41
 gangrene, 299
 in inguinal hernia, 45
 intestinum posterium, 6
 location, 41
 malignant disease, 227
 mobile, 315
 of Galen, 6
 peritoneal covering, 43
 tuberculosis, 227, 232
 types, 42
 Calculi, appendicular, in children, 198
 in appendicitis, 166
 Calculus of appendix, 95
 renal, 240
 ureteral, 192, 240
 Carcinoma of appendix, 117
 age in, 118
 benignancy, 121
 location, 120
 malignancy, 121
 sex, 120
 cæcum, 227
 Catarrhal appendicitis, acute, 83
 chronic, 104
 Chicken-pox in appendicitis, 77
 Children, appendicitis in, 196
 Chills in appendicitis, 184
 Cholecystitis, 235
 gangrenous, 235
 phlegmonous, 235
 Cholelithiasis, 236
 Cigarette drain, 292
 Clado's ligament, 47
 point, 179
 Coccus conglomeratus, 152
 Colica dextra artery, 56
 "Colic passion," 9
 Colitis, 221, 346
 Colloid degeneration of appendix, 107
 Colon, ulcer, perforation, 228
 Concretions of appendix, 95
 Constipation in appendicitis, 73, 182
 Cyst of appendix, 67
 ovarian, 246
 Cystic dilatation of appendix, 107
 Davis incision, 37
 Dawbarn's purse-string suture, 37
 Deaver's incision, 37
 Diagnosis, abscess, 215
 appendicitis, acute, 209
 chronic, 191
 typhoid, 203
 chills, 218
 distention, 215
 fever, 214
 gangrene, 216
 leucocytes, 216
 opium, 210
 pain, 210, 217
 rigidity, 213
 serum, 216
 summary, 216
 tenderness, 212
 three cardinal symptoms, 209
 vomiting, 212
 Diaphragmatic pleurisy, 200
 Diarrhoea in acute appendicitis, 182
 Differential diagnosis, 219
 abscess, hepatic, 236
 kidney, 239
 ovarian, 245
 peri-hepatic, 236
 peri-nephric, 242
 affections of gall-bladder, 206
 biliary duct disease, 234
 calculus, renal, 240
 ureteral, 240
 carcinoma, cæcum, 227
 cholecystitis, 235
 cholelithiasis, 236
 colitis, 221
 cyst, ovarian, 246
 diaphragmatic pleurisy, 200

- Differential diagnosis, diverticulitis, 227
 dysentery, 221
 dysmenorrhœa, 244
 empyema, gall-bladder, 235
 enteralgia, 220
 enteritis, acute, 220
 enterospasm, 222
 floating kidney, 241
 gall-bladder disease, 234
 gastritis, acute, 220
 gastro-duodenal catarrh, 220
 gastro-enteritis, 199
 gastro-intestinal inflammation, 219
 in children, 199
 intestinal colic, 220
 hæmorrhage, 206
 obstruction, 226
 perforation, 205
 stasis, 222
 intussusception, 199
 kidney disease, 239
 menopause, 244
 movable kidney, 238
 nephritis, toxic, 241
 oophoritis, 245
 pancreatitis, acute, 236
 chronic, 237
 pelvic disease, 195
 pleurisy, 247
 pneumonia, 200, 247
 pregnancy, extra-uterine, 243
 pylorospasm, 194
 pyonephrosis, 239
 pyosalpinx, 245
 renal colic, 240
 salpingitis, 244
 sarcoma of cæcum, 231
 secretory neuroses, 194
 summary, 195
 thrombosis, femoral vein, 206
 iliac vein, 206
 torsion of omentum, 247
 tuberculosis of cæcum, 227, 232
 ileum, 232
 mesenteric glands, 232
 typhlitis, 223
 typhoid, 204, 232
 perforation, 205
- Differential diagnosis, ulcer, gastro-intestinal, perforated, 224
 of colon, perforated, 228
 of duodenum, 224
 perforated, 225
 of stomach, 224
 perforated, 225
 upper abdominal disease, 193
 ureter, affections of, 239
 ureteritis, 240
- Distention, general, 217
 localized, 217
 in appendicitis, acute, 186
- Diverticulitis, 227
- Diverticulum of appendix, 108
- Drainage, post-operative, 291, 320
- Dysentery in appendicitis, 74, 221
- Dysmenorrhœa, 244
- Dyspepsia, appendicular, 193
- Ecphyaditis, 27
- Edebohl's incision, 37
- Eliot's incision, 37
- Empyema, 343
 of appendix, 91
 of gall-bladder, 235
- Endothelioma of appendix, 123
- Enemas, 273
- Enteric fever, 232; vide typhoid fever
- Enteritis, acute, 220
- Enteroclysis, 271, 327
 method of administration, 272
- Enterospasm, 222
- Epityphlitis, 27
- Exciting causes of appendicitis, 69, 77, 164
- Femoral vein, thrombosis, 139
- Fever as a symptom, 183
 in children, 198
- Fibro-myoma of appendix, 116
- Fistula, appendicular, 305, 334
 treatment, 310
 bimucous, 96
 fæcal, 305
 external, 306
 treatment, 310
 internal, 309
 operation, 311

- Fistula, fæcal, symptoms, 310
 simple, 311
 Foreign bodies in appendix, 165
 Fossa, ileo-cæcal, 61, 64
 inferior, 64
 superior, 64
 ileo-colic, 61
 peri-cæcal, 64
 retro-colic, 64
 sub-cæcal, 64
 Fossæ, peritoneal, 61
 Fowler's position, 38
 Fulminating appendicitis, 100

 Gagen-Thorn's incision, 37
 Gall-bladder disease, 234
 empyema of, 235
 Gangrene of appendix, 58, 99
 in children, 198
 of cæcum, 299
 Gangrenous appendicitis, 99
 Gastric dilatation, prevention of, 325
 ulcer, 224
 perforated, 225
 Gastritis, acute, 220
 Gastro-duodenal catarrh, 220
 Gastro-enteritis, in children, 199
 in appendicitis, 73
 Gerlach's valve, 156
 "Grid-iron" incision, 37
 Glass drainage tube, 292, 320
 care of, 332
 Gauze, coffer-dam, 290
 use of in suppuration, 290
 Gauze-drainage, 291
 removal, 295

 Hæmaglobin in appendicitis, 252
 Hæmorrhagic peritonitis, 143
 Hancock's incision, 284
 Harrington's incision, 37
 Hepatic abscess, 139, 236
 Hepatitis, suppurative, 338
 Hernia as complication, 347
 post-operative, 313
 operation for, 314
 prevention of, 313
 through meso-appendix, 47
 ventral, 313

 Hiatus muscularis, 55
 Hiccough in appendicitis, 182
 Histology of appendix, 54
 History, 1
 abscess of appendix, first laparotomy, 33
 opened, 32
 operations for, 33, 34, 35
 peri-appendicular, first recovery, 13
 rupture, 9
 into bowel, 18
 absence of appendix, 21
 adversaria anatomia, 7
 anatomy of appendix, 4
 apophysis, 11
 appendicitis, earliest case, 12, 15
 first case in America, 17
 obliterans, 28
 pain in, 13
 suggestion of operation, 18
 term first used, 27
 appendicula, 11
 removal, 12
 appendix, bacteriology, 27
 extraction of calculus, 18
 first removal, 30
 interval removal, 36
 in hernia, 14
 not found, 8
 obliterated, 16
 obliteration of lumen, 21
 pathology, 21, 26
 pin in, 31
 birds, cæcum in, 7
 cæcum of Galen, 6
 Clado's ligament, 9
 clinical cases of appendicitis, 9
 data, 9
 colic passion, 9
 concretions in appendix, 8, 16
 ecphyaditis, 27
 epityphlitis, 27
 fæcal impaction, 19
 first case of appendicitis, 15
 in America, 17
 interval operation, 36
 foreign bodies in appendix, 16, 21
 Fowler position, 38

- History, Gerlach's valve, 9
 Hippocrates, cause of death, 12
 iliac passion, 9
 incisions for appendicitis, 37
 McBurney's point, 27
 malignant tumor of cæcum, 19
 Murphy treatment, 38
 of peritonitis, 38
 Ochsner treatment, 38
 peri-cæcal fossæ, 9
 peritoneal fossæ, 8
 peritonitis appendicularis, 26
 peri-typhlitis, 23
 phlegmonous mass of cæcum, 19
 phlegmons, extraperitoneal, 25
 intra-peritoneal, 25
 pin in appendix, 16
 quince seed in appendix, 11
 résumé, 39
 retro-cæcal cellulitis, 19
 scolecoiditis, 27
 stercoral typhlitis, 23
 treatment, 28
 by application of puppy-dog, 30
 by Boerhaave, 30
 by bullets, 29
 by emetics, 29
 by enemas, 29
 by horseback riding, 30
 by hot oil baths, 29
 by lead pills, 29
 by leeches, 33
 by opium, 33
 by purgatives, 29
 by quicksilver, 29
 by shot, 16
 by venesection, 28
 first removal, 30
 tuberculosis of appendix, 21, 23
 typhlitis, chronic, 23
 simple, 23
 valve of appendix, 8
 worms in appendix, 8
 Hydatid cyst of appendix, 116
 Hydronephrosis, 146
 Hydrops of appendix, 107
 Hyperalgesia, cutaneous, 181
 Hyperpyrexia, in appendicitis, acute,
 184
 Icterus in appendicitis, 184
 Ileo-cæcal artery, 56
 fold, 61
 fossa, 61, 64
 inferior, 64
 superior, 64
 Ileo-colic artery, 56
 fold, 61
 fossa, 61
 lymph glands, 58
 vein, 58
 Iliac fossa, blood supply, 56
 passion, 9
 vein, thrombosis, 139
 vessels, necrosis, 337
 Ilio-psoitis, 139
 Incision, Battle's, 37, 282
 Davis, 37
 Deaver's, 37
 direct, 281
 Edebohl's, 37
 Eliot's, 37
 Gagen-Thorn's, 37
 "grid-iron," 37, 284
 Hancock's, 284
 Harrington's, 37
 indirect, 281
 Jalaguier's, 37, 282
 Kammerer's, 37, 282
 Lennander's, 37
 McBurney's, 37, 284
 muscle-splitting, 37, 284
 oblique, 285
 rectus displacement, 283
 splitting, 282
 straight, 37
 Wier's, 37
 Incisional hernia, 313
 Indigestion in appendicitis, 193
 Infection abdominal wall, 312
 "Inflammation of bowels," 209
 Influenza in appendicitis, 75
 Interstitial appendicitis, acute, 87
 chronic, 105
 Interval operation, 360
 Intestinal colic, 220
 stasis, 222
 obstruction, 226
 Intestine, embryology, 41

- Intestine, necrosis, 336
 - obstruction, 346
- Intussusception of appendix, 248
 - in children, 199
- Iodine reaction, 257
- Irrigation in appendicitis, 293
 - in peritonitis, 293
- Jalaguier's incision, 37, 282
- Kammerer's incision, 37, 282
- Kidney, abscess, 139
 - diseases, 239
 - floating, 241
 - movable, 238
- Lane's kink, 315
- Lavage, post-operative, 325
- Length of appendix, 43
- Lennander's incision, 37
- Lesions of appendix, 83
- Leucocytosis, 252
 - in appendicitis, acute, 185
 - in diagnosis, 216
 - in prognosis, 256
 - table, 256
- Ligament, appendiculo-ovarian, 47, 58
 - of Clado, 47
- Lipoma of appendix, 116
- Liver, abscess, 139
- Lymph-adenitis, 139
- Lymph-adenoma of appendix, 116
- Lymphangitis, 139
- Lymphatics of appendix, 58
- Lymph gland, appendicular, 58
 - ileo-colic, 58
- Lympho-sarcoma of appendix, 124
- McBurney's incision, 37
 - point, 27
- Macroscopy, appendicitis, acute, catarrhal, 84
 - gangrenous, 99
 - interstitial, 88
 - ulcerative, 92
 - chronic, catarrhal, 104
 - interstitial, 105
 - obliterating, 111
- Measles in appendicitis, 77
- Medical treatment, 355
- Menopause, 244
- Menstruation, painful, 244
- Mesenteric glands, 232
- Meso-appendix, 45
 - in ætiology, 155
- Microscopy, appendicitis, acute, catarrhal, 85
 - gangrenous, 101
 - interstitial, 88
 - ulcerative, 97
- catarrhal, 85
 - chronic, catarrhal, 105
 - interstitial, 109
 - obliterative, 112
- Movable kidney, 238
- Mucocoele of appendix, 107
- "Muscle-splitting" incision, 37
- Myoma of appendix, 116
- Myxo-sarcoma of appendix, 126
- Nationality in appendicitis, 72
- Nausea in appendicitis, acute, 182
 - post-operative, 325
- Necrosis, iliac vessels, 337
 - intestine, 336
- Nephritic colic, 240
- Nephritis, toxic, 241
- Nerve, eleventh dorsal, 59
 - first lumbar, 59
 - twelfth dorsal, 59
- Nerves of appendix, 59
- Nutrient enemias, 328
- Oblique incision, 285
- Obliterating appendicitis, 107, 111
- Obstruction, intestinal, 303, 346
 - post-operative, 303
 - treatment, 304
- Ochsner's treatment, 38
- Omentum, abscess, 302
- Oophoritis, 245
- Operation, adhesions, 298
 - after-treatment, 323
 - abdominal supporters, 313
 - lavage, 325
 - morphia, 326
 - nourishment, 326
 - opium, 326

- Operation, after-treatment, posture, 323
- saline, 326
 - enemas, 328
 - enteroclysis, 327
 - special, 329
 - stimulants, 325
 - urine, 328
- amputation of appendix, 287
- anæsthetic, 279
- anæsthetist, 280
- appendicostomy, 333
- cardiac murmur, 265
- closure of abdomen, 318
- complications, 297
- table, 351
- drainage, 291, 292
- examination of patient, 277
- fistula, fæcal, 311
- following peritonitis, 274
- for abscess, 290
- gangrene of cæcum, 299
- gauze coffer-dam, 290
- hernia, post-operative, 314
- incision, abdominal, 281
- Battle's, 282
 - direct, 281
 - "gridiron," 284
 - Hancock's, 284
 - indirect, 281
 - Jalaguier's, 282
 - Kammerer's, 282
 - McBurney's, 284
 - median, 281
 - muscle-splitting, 284
 - oblique, 285
 - rectus displacement, 283
 - splitting, 282
- in clean cases, 286
- in diffuse peritonitis, 296
- in diffusing peritonitis, 267
- in renal disease, 266
- in suppurative cases, 289
- interval, 360
- irrigation, 293
- organic disease, 265
- pain, post-operative, 315
- peritonitis, after-treatment, 332
- preparation of patient, 277
- renal sufficiency, 277
- Operation, sequels, 300
- abscess, omentum, 302
 - properitoneal, 312
 - secondary, 300
 - stitch, 313
 - adhesions, 316
 - fistula, appendicular, 305
 - fæcal, 305
 - hernia, 313
 - obstruction, 303
 - pain, 315
 - pneumonia, 344
 - sutures, 319
 - technic, 277
 - time for, 266
 - treatment of stump, 289
 - "walling off," 291
 - wound, closure, 318
 - drainage, 320
 - dressing, 320
- Opium in after-treatment, 326
- in treatment, 273
 - use of, 222
- Ovary, abscess, 245
- cyst, 246
- Pain as symptom, 176
- at McBurney's point, 59
 - hepatic, 217
 - ileo-cæcal, 223
 - in appendicitis, acute, 176
 - secondary, 178
 - chronic, 192
 - in children, 198
 - in cicatrix, 317
 - in diagnosis, 210, 217
 - initial, 177
 - left-sided, 217
 - location of, 178
 - post-operative, 315
 - recurrence of, 178
 - referred, 178
 - explanation of, 59
 - from appendix, 59
 - to testicle, 59
 - reflex, 59
 - secondary, 178
 - subsidence of, 178
- Palpation, 187

- Pancreatitis, acute, 236
 chronic, 237
 Parasites, intestinal, 79
 Para-typhlitic abscess, 136
 Para-typhoid of Dieulafoy, 201
 Parotitis, 344
 Pathogenesis of appendicitis, 69, 154.
 (Vide ætiological factors.)
 Pathology of appendicitis, 80
 acute interstitial, 90
 chronic, 102
 in children, 197
 Percussion, 188
 Perforation during typhoid, 202
 of appendix, 58, 93
 of ulcer, colic, 228
 duodenal, 225
 gastric, 225
 gastro-intestinal, 224
 Peri-cæcal fossa, 64
 Peri-hepatitis, 139
 Peri-nephric abscess, 242
 Peri-renal abscess, 136
 Peritoneal adhesions, 144
 fossæ, 61
 sepsis, 143
 Peritonitis, 126
 appendicular, 127, 130, 144
 bacteria in, 128
 circumscribed purulent, 133
 serous, 130
 clinical manifestations, 129
 consequences of, 129
 diffuse, 140
 purulent, 136
 fibrinous, 130, 132
 generalized, 140
 hæmorrhagic, 143
 intoxication from, 129
 operation, after-treatment, 332
 post-operative, treatment, 324
 progressive fibrino-purulent, 140
 purulent, operation, 296
 putrid, 143
 septic, 143
 sero-fibrinous, 130
 suppurative, 141
 therapeutic, 269
 toxic, 129, 143
 typhoid, 207
 Peritoneum, powers of resistance, 127
 Peri-typhlitic abscess, 133
 Peri-typhlitis, 23
 Phlebitis, 337
 Physiology of appendix, 66
 of cæcum, 66
 Pin in appendix, 16
 Pleuritis, 139
 Pleurisy, 247, 343
 "Plica Vascularis," 58
 Pneumococcus, 152
 Pneumonia, 247, 344
 Polyp of appendix, 116
 Portal vein, phlebitis, 139
 Position of appendix, 47
 Post-operative treatment, 323
 Posture in appendicitis, 185
 post-operative, 323
 Predisposing causes of appendicitis, 60,
 155
 Pregnancy in appendicitis, 350
 extra-uterine, 243
 Prenatal appendicitis, 69
 Primary typhlitis, 209, 223
 Preparation of patient, 277
 Prognosis, 258
 in abscess, 261
 in children, 200
 in peritonitis, 261
 in typhoid appendicitis, 206
 leucocytosis in, 256
 mild cases, 259
 opium in, 260
 recurrent attacks, 262
 suppurative cases, 259
 treatment as factor, 260
 with intercurrent disease, 261
 Pseudo-appendicitis, 223
 Pseudo-cyst of appendix, 108
 Pulmonary abscess, 137, 139
 Pulse rate as symptom, 184
 Purpura hæmorrhagica in appendicitis, 77
 Purse-string suture, 37
 Purulent appendicitis, 85
 Putrid peritonitis, 143
 Pyelephlebitis, 139
 Pyemia, 344
 Pylorospasm, 194
 Pyonephrosis, 146, 239
 Pyosalpinx, 245

- Rectus muscle, incision through, 282
 displacement of, 283
 Recurrence of pain, 178
 Recurrent appendicitis, 191
 Referred pain, 178
 Reflex, viscero-muscular, 59
 Relapsing appendicitis, 82, 105, 190
 Renal abscess, 139, 239
 colic, 240
 Respiration as symptom, 184
 Restlessness as symptom, 176
 Retro-colic fossæ, 64
 Retro-peritoneal abscess, 96, 137
 Rigidity of abdominal muscles, 181
 Rovsing's symptom, 180
- Salpingitis, 244
 Sarcoma of appendix, 124
 of cæcum, 231
 Scarlet fever in appendicitis, 77
 Scolecoiditis, 27
 Season in appendicitis, 73
 table, 71
 Sepsis, peritoneal, 143
 Septic peritonitis, 143
 Sequels, 335. (Vide complications.)
 of operation, 300
 Serum diagnosis, 216
 Sex in appendicitis, 69
 table, 70
 Sex in carcinoma of appendix, 120
 Spleen, abscess of, 139
 Starvation treatment, 38
 Stercoral typhlitis, 23
 Stitch abscess, 313
 Straight incision, 37
 Subcæcal fossa, 64
 Subdiaphragmatic abscess, 137
 Subperitoneal veins, 58
 Subsidence of pain, 178
 Supporters, abdominal, 313
 Superior mesenteric artery, 56
 Surgical treatment, 264
 Suture, purse string, 37
 Symptomatology, 175
 auscultation, 189
 inspection, 186
 palpation, 187
 percussion, 188
 summary, 195
- Symptoms of appendicitis, acute, 176
 chronic, 192
 in children, 198
 typhoid, 204
 bladder, 183
 chills, 184
 condition of patient, 185
 constipation, 182
 cutaneous hyperæsthesia, 181
 diarrhœa, 182
 distention, 186
 hiccough, 182
 hyperpyrexia, 184
 icterus, 184
 leucocytosis, 185
 nausea, 182
 pain, 176
 initial, 177
 left-sided, 217
 secondary, 178
 posture, 185
 pulse rate, 184
 respiration, 185
 rigidity of abdominal muscles, 181
 temperature, 183
 tenderness on pressure, 179
 superficial, 181
 three cardinal, 176
 tumor, 187
 urinary, 185
 vomiting, 182
- Synonyms for appendicitis, 27
- Technic of operation, 217
 Temperature in acute appendicitis, 183
 Tenderness on pressure, 179
 decreased, 217
 in children, 198
 increased, 217
 position of, 180
 superficial, 181
 with pus, 217
- Testicle, pain in, 29
 "Therapeutic peritonitis," 269
 Three cardinal symptoms, 176
 Thrombo-phlebitis, 139
 Thrombosis, femoral vein, 139
 iliac vein, 139
 Tonsil, abdominal, 42, 54
 Tonsillitis in appendicitis, 75

- Torsion of omentum, 247
- Toxic peritonitis, 143
- Trauma in appendicitis, 78
- Treatment, alimentation, 273
 - anodynes, 273
 - between attacks, 275
 - early operation, 264
 - enteroclysis, 271
 - fluids by mouth, 270
 - food, 270
 - ice-bags, 270
 - lavage, 270
 - medical, 355
 - Ochsner's, 38
 - of adhesions, post-operative, 317
 - of appendicitis, acute, 264
 - chronic, 195
 - in children, 200
 - typhoid, 207
 - of fistula, appendicular, 310
 - external, 310
 - faecal, 310
 - simple, 311
 - of obstruction, post-operative, 304
 - of peritonitis, diffuse, 269
 - post-operative, 323
 - proctoclysis, 271
 - purgation, 269
 - sitting posture, 270
 - surgical, 264
- Tuberculosis complicating appendicitis, 348
 - in appendicitis, 78
 - of appendix, 113
 - of cæcum, 232
 - of ileum, 232
 - of mesenteric glands, 232
- Tumor in appendicitis, acute, 187
- Tumors of appendix, 116
- Typhlatonia, 316
- Typhlitis, 23, 223
 - chronic, 23
 - primary, 209, 223
 - simple, 23
 - stercoral, 23
- Typhoid appendicitis, 97, 201
 - diagnosis, 202
 - treatment, 207
- Typhoid fever, 232
 - in appendicitis, 74
 - peritonitis, 207
 - perforation, 205
- Ulcer, colon, perforated, 228
 - gastro-intestinal, perforated, 224
 - duodenal, 224
 - perforated, 225
 - gastric, 224
 - perforated, 225
- Ulcerative appendicitis, acute, 92
- Ureter, affections of, 239
- Ureteritis, 240
- Urine in acute appendicitis, 185
 - post-operative, 328
- Valve, of appendix, 54
 - of Gerlach, 9, 54, 156
- Vein, femoral, thrombosis, 139
 - ileo-colic, 58
 - subperitoneal, 58
- Veins of appendix, 58
- Viscero-muscular reflex, 59
- Vomiting in acute appendicitis, 182
 - post-operative, 325
- Wier's incision, 37
- Wound, closure of, 318
 - dressings of, 320
 - suture of, 314
- Wright's solution, 320

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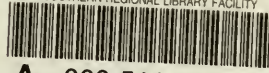
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